Traffic Barriers: The Impact of Traffic on Pedestrian Behaviour

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ABSTRACT

This thesis addresses relationships between traffic conditions and pedestrian behaviour, relationships which determine the extent of traffic barrier effects. These relationships have been examined on selected high density, radial mixed use streets, in Edinburgh, which are important routes for pedestrians and vehicular traffic. Data was collected and analysed from video recordings which provided measures of traffic and pedestrian flow, traffic speed, and pedestrian crossing behaviour; questionnaire surveys and personal in-depth interviews of changing pedestrian perceptions in response to changes in traffic conditions.

Traffic flow was seen to be a principal determinant of traffic barriers on such central urban streets. High traffic barrier effects were associated with heavy traffic flows and low speeds, and were characterised for pedestrians by smaller acceptance gaps, longer delays, steeper crossing angles and by high proportions of crossings from behind parked vehicles. Elderly and child pedestrians were particularly badly affected, with very low crossing activity levels compared with adults. Respondents, in both questionnaire surveys and in-depth interviews, found crossing a difficult and stressful experience. Many stated that in response to adverse traffic conditions, routes were changed, walking rescheduled or abandoned altogether, and crossing locations changed from informal to formal crossing points.

The findings are related to issues involved in the design and implementation of traffic calming and traffic management schemes, where pedestrian mobility, as well as safety objectives, require explicit consideration. Further research is proposed to develop practical indicators of the barrier effect for use in the design and monitoring of schemes.

ABBREVIATIONS

DTp - Department of Transport

IHT - Institute of Highways and Transportation

SNRA - Swedish National Roads Administration

SWOV - Dutch Institute for Road Safety Research

OECD - Organisation for Economic Co-operation and Development

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

This thesis contributes new evidence to current discussions concerned with pedestrian provision in cities and the need for an enhanced understanding of the impacts of traffic on pedestrian behaviour. The consideration of pedestrian issues and needs has now been identified as being important to both city planning and traffic management. In particular the impact of traffic on pedestrians and their street activity has been identified as an important policy area worthy of more consideration. Pedestrian friendly environments are considered as generically "good" for cities, introducing civilising qualities and encouraging increased numbers of pedestrians to penetrate shopping areas on foot, whilst reducing the potential for conflict with motorised traffic within them (TEST, 1988a; Pharoah, 1992). Residential developments, both old and new, are now incorporating traffic management or traffic calming schemes aimed at reducing the intrusiveness of motor traffic and its speed (Hass-Klau, 1992; Devon County Council, 1991). The problem however is that where schemes have been introduced there is little understanding of the effects that these schemes have on pedestrian perceptions and behaviour, especially in circumstances where the impact of motorised traffic has been reduced or where a street experiences changes in the nature of traffic over time.

Until recently the role of walking and its importance was consistently underestimated by policy and decision makers in our towns and cities (Hillman, 1974; National Consumer Council, 1987; Hine and Russell, 1990). This underestimation of the requirements of pedestrians has resulted in a pre-occupation with the effects of pedestrianisation of shopping streets in central areas on pedestrian movement and behaviour at the expense of studies of pedestrian behaviour and movement elsewhere in the street network (National Consumer Council, 1987; Hall and Hass-Klau, 1985; Roberts, 1981; TEST, 1981; 1988a; Norwich City Council, 1969; 1987; York City Council, 1988). On the whole, studies investigating the impact of traffic calming and traffic management schemes on pedestrian crossing behaviour have tended to ignore pedestrian movement and behaviour studies. Such a situation has arisen as a result of the time-consuming and costly nature of data collection and analysis associated with pedestrian behaviour studies.

It has nevertheless been shown that speed reduction techniques such as traffic calming, when they are combined with environmental improvements or the pedestrianisation of streets in order to minimise the intrusions made by motor traffic, create places where people feel safe, and where the street is perceived as possessing a pleasant pedestrian environment (Hass-Klau, 1986; TEST 1988a). These perceptions result in modifications of behaviour. For example, people are willing to spend more time in the street (Appleyard and Lintell, 1969; Gehl, 1987; Eubank-Ahrens, 1987). Evidence, from before and after studies in Denmark and elsewhere, suggests that the "fence effect" of traffic can be substantially reduced following the introduction of traffic calming measures (Danish Ministry of Transport, 1987). This fence-effect is an ill-defined term used by Danish researchers referring to the reduction in impact of traffic flow and speed on pedestrians and cyclists. None of these studies have sought to address the relationships between changing traffic flow and speed levels, and resulting changes in pedestrian behaviour. This thesis focuses on these relationships and the more accessible term "traffic barrier". As is discussed more fully below, the concept "traffic barrier" refers directly to the impact of changing levels of traffic volume and speed, in determining the extent of the barrier and the nature of its effects on pedestrians in a street environment.

All of the literature points to the need for increased understanding of the impact of traffic on pedestrian behaviour and how and why pedestrian behaviour changes in response to changes in traffic conditions. This study addresses these relationships between changing traffic conditions and pedestrian crossing behaviour and activity. In order to do this the study adopts a methodology which uses a battery of research techniques. The study is primarily based on video analysis of observable pedestrian behaviour. This provides new quantitative evidence of changes in observable pedestrian behaviour in response to changing traffic conditions. Also, the use of video analysis enabled a fuller analysis of this than was possible in the past. However the video cannot provide data on pedestrians' perceptions - or the reasons why pedestrians change their behaviour. To address this problem the video surveys have been supplemented by questionnaire surveys and in-depth interviews aimed at obtaining data relating pedestrian perceptions and attitudes to the impact of traffic on pedestrian behaviour.

The focus of the study is on streets in Edinburgh which have a residential/retail mix. This is a characteristic feature on radial routes approaching central areas of Scottish cities, with the ground floor of the tenements fulfilling a retail use and the upper floors residential. These radial routes have important traffic functions and serve as important public transport routes. Thus the focus is on streets in which major pedestrian and vehicular conflicts arise, and on which there is a concentration of reported accidents.

1.2 DEFINING THE TRAFFIC BARRIER CONCEPT

In addressing the relationships between traffic and the pedestrian this thesis refers to a key concept - the "traffic barrier". The notion of traffic barriers and the measurement of barrier effects is an important one, for consideration by both town planners and traffic engineers, which requires further development. The concept of traffic barrier should be seen within the broader context of behavioural adaptation (OECD, 1990). The importance of such a concept as "traffic barriers" has been implicitly recognised in the existing literature. The lack of explicit recognition means that the potential role and function of traffic barriers and their relationship to pedestrian behaviour has only been stated in ill-defined general terms.

Everett and Watson (1987) have indicated that many transportation professionals clearly perceive the need for a better understanding of road user behaviour. This need for a clearer insight into transport systems from a human perspective rather than from an exclusively technological view has been recognised (Appleyard, 1979; Craik, 1969; Galer, 1979; Hartgen, 1978, 1981; Kreindler, 1979). Although no definition of the traffic barrier and its effects exists in the literature, a similar concept is that of severance which is provided by the Department of Transport in the U.K.. This states that severance can be defined as the "sum of the divisive effects a major urban road or heavy traffic flow has on the inhabitants either side of it. These effects can be either physical (i.e. actual barriers to movement) or psychological (i.e. perceived impediments to movement)" (DTp/IHT, 1987, P75). This definition is problematic in that it is unnecessarily limiting by reference only to inhabitants. As a consequence, it undervalues the movement requirements of pedestrians. Also severance has been associated with new road provision, where existing links between communities and neighbourhoods have been severed as a result. The term therefore has connotations which are not appropriate for assessing the impact of traffic on pedestrian behaviour where a gradual increase in the traffic barrier has evolved over time with increases in traffic levels. Nevertheless it does indicate that heavy traffic levels are often identified as having physical and psychological effects on pedestrians. This is an important starting point and one which this thesis aims to build upon.

There is wide recognition of the need to address issues relating to the quality of pedestrian environments and the need for adequate assessment of the impacts of new road developments and adverse traffic conditions on pedestrian behaviour (Buchanan, 1963; Urban Motorways Project Team, 1973a; 1973b; DTp, 1992c). Pharoah has commented:

> "Improving the quality of urban life means more than just providing the occasional shopping precinct or riverside walk. It requires the creation of comfortable and pleasing surroundings throughout the fabric of buildings, streets and spaces which people can use without fear or intimidation or inconvenience imposed by motor traffic" (Pharoah, 1992, P12).

Buchanan (1963) has also recognised that the quality of the environment was strongly associated with the freedom of pedestrian movement and accordingly proposed a methodology by which the environmental capacity of streets could be assessed:

> "All this suggests that with further knowledge it would be possible to take any existing street and after examination of its dimensions, the uses and character of the adjoining buildings, and the amounts of pedestrian traffic along and across it, to define the volume and character of the traffic permissible in the street consistent with the maintenance of good environmental conditions" (Buchanan, 1963, P50).

More recently the Standing Advisory Committee on Trunk Road Assessment has indicated that further work needs to be done on issues surrounding severance (DTp, 1986). In 1992 the Committee suggested in a new Environmental Assessment Manual that personal stress should also be assessed:

> "We do not believe that the present headings - community severance, driver stress and effects on pedestrian and cyclists - necessarily capture all the impacts of road schemes and traffic on human beings, individually or communally" (DTp, 1992c, P66).

Clearly the quality of pedestrian environments, in terms of the relationship between motorised traffic and pedestrian needs has been identified as an important area of policy. Recognition that environmental conditions such as traffic levels affect pedestrian behaviour and activity has been accompanied by the advocacy of methodologies relating to the assessment of the impact of traffic on pedestrian behaviour. The indications are however that while there is an implicit acknowledgement of the need to quantify and define the effects of traffic on pedestrian behaviour this has only been stated generally and in ill-defined terms. The concept of traffic barriers, their potential role and function in relation to pedestrian behaviour should be explored more fully.

1.2.1 Behavioural adaptation

A separate strand of thought begins to highlight similar issues. The OECD (1990) in a recent report outlined the epistemology of the term behavioural adaptation and investigated the evidence for behavioural adaptation of drivers following changes in the road transport system. The report set out the concept formally and indicated that because this had only been done recently there was a need to develop a body of research to provide explanations of behavioural adaptation. In focusing on the term behavioural adaptation the report noted:

> "Behavioural adaptation is neither a theory nor an hypothesis. Rather it is a term which describes measurable behaviour changes, which are unintended, and which occur following a road safety programme (safety education, change to a vehicle, or modification to the road network). It is at the same level of abstraction as a concept in a theory, in that it cannot be itself operationalized, but specific instances of it can be operationalized. Therefore, it can be measured and studied as a dependent measure in road safety research, with the operational definition dependent on the exact context of the research.....The operational definitions are applicable to the specific example, but the effects observed can be described as examples of behavioural adaptation" (OECD, 1990, P20).

The report also outlines five assumptions associated with behavioural adaptation:

1) For behavioural adaptation to occur it must be assumed that there is feedback to road users, that they can perceive the feedback (but not necessarily consciously), that road users have the ability to change their behaviour and that they have the motivation to change their behaviour. Feedback refers to knowledge and information received from the system or environment which results from changes in road users' behaviour.

2) Feedback occurs at a number of different levels. There is immediate feedback which would for example involve the perception of a newly installed traffic sign. Next there is feedback from the system components, the vehicle, the road, the driver and other road users. This provides road users with information about how their responses to the initial

change is affecting vehicle performance and the behaviour of other road users, as well as how the initial change in behaviour is affecting personal goals. In addition subtle feedback can be experienced which results from observing the road system over time, and detecting changes in other road users' behaviours and the occurrence of incidents in the traffic system such as accidents and near-collisions.

3) For behavioural adaptation to occur it must be assumed that road users can change their behaviour in response to the feedback that they receive.

4) For behavioural adaptation to occur, there must be some motivation to change behaviour. If a safety feature is perceived to improve safety, and the road user enjoys the added safety benefit, then there is little motivation to change behaviour to take advantage of the system change. For example if a safety programme is successful it can convince road users that a situation is dangerous and suggest a chance to reduce danger. If road users accept the suggested behavioural change they must be accepting the premise of a dangerous situation. However other road users may absorb the safety benefits in improved performance resulting in decreased travel time, increased travel distance or some other motivation which is of greater significance to the individual than increased safety.

5) Behavioural adaptation occurs after the initial response and is a process during which road users incorporate the change into their normal behaviour, modifying the initial response on the basis of their perceptions of the vehicle, the road, other road users and their personal goals of safety and mobility (OECD, 1990, P20-23).

Behavioural adaptation has been defined by the OECD in the context of road safety. It refers to the road-vehicle-user system which embraces the environmental context within which behavioural adaptation occurs. The definition does not, however, provide any suggestion as to the motivating factors which might cause behavioural change:

> "Behaviour adaptations are those behaviours which may occur following the introduction of changes to the road-vehicle-user system and which were not intended by the initiators of change;
> Behavioural adaptations occur as road users respond to changes in the road transport system such that their personal needs are achieved, as a result they create a continuum of effects ranging from a positive increase in safety to a decrease in safety" (OECD, 1990, P23).

The term behavioural adaptation is not new, and has become important following the work of Wilde (1982a; 1982b) in which adaptation to changing situations in the road system is outlined. The OECD definition of behavioural adaptation, referred to above, has a severe limitation in that it does not specify a spatial or temporal range. Ideally spatial and/or temporal aspects should be specified and should address linkages between environment and behaviour (OECD, 1990; Evans, 1985). Behavioural adaptation should also not be seen as a term which is used solely in relation to changes in the road system which are instituted for the purposes of safety (OECD, 1990, P22).

1.2.2 The traffic barrier

The concept of behavioural adaptation, as described above, is clearly relevant to pedestrian behavioural change. The concept of a traffic barrier provides one context within which behavioural adaptation, a much wider concept, takes place. This thesis focuses on the traffic barrier and on the idea of severance to develop a more precise concept related to pedestrian activity and behaviour. In both concepts behavioural adaptation occurs as a result of perceived feedback to road users and behavioural change occurs as a result of motivation to change (for example trade-offs between pedestrian mobility and safety represents one such motivation to change).

The behavioural adaptation concept as defined by the OECD (1990) refers to measurable behavioural changes of all road users (in the report the concept is addressed specifically in terms of driver behaviour) resulting from changes to the legal, vehicle interior and street/road environments. The traffic barrier concept is a refinement of this. It is more specific in scope, being concerned with pedestrians only and addressing changes in observable pedestrian behaviour in response to changes in the traffic environment as mediated by perceptions. As with the concept of behavioural adaptation the traffic barrier concept is at the same level of abstraction as a concept in a theory in that it cannot itself be operationalised or measured, but specific aspects of it can be. This indicates that the measures used to assess the traffic barrier are only partial. Various measures have been used to assess the impact of the traffic barrier effect on pedestrian behaviour in previous work and are referred to in the existing literature (see chapters 2 and 3).

The traffic barrier can therefore be defined as:

> "the sum of inhibiting effects upon pedestrian behaviour resulting from the impact of traffic conditions within a specified environmental/street context. These effects can be either physical (observable) and psychological (unobservable) impediments to pedestrian movement.
>
> Variations in the extent to which the traffic barrier effect is experienced

can be influenced by individual pedestrian characteristics (age, walking situation, personal experiences) and trip characteristics (journey importance, trip type)."

It is therefore apparent that the traffic barrier:

i) is a complex construct associated with specific forms of severance affecting pedestrians and their behaviour;

ii) relates to specific places and times, and can only be specified in its context;

iii) is both physical and psychological. While its effects can be observed in patterns of behaviour, while the psychological dimension, involving perceptions as reasons for changing behaviour, will involve trade-offs between pedestrian safety and mobility and other factors which are not identifiable through observation.

The traffic barrier concept then relates to a set of traffic conditions within a specific street environment (context) and to perceptions of those conditions. The effect of the traffic barrier is manifested by observable behavioural response to those conditions, and within this, the importance of feedback or perceptions, in terms of mediating behavioural outcomes is implicitly recognised (Eiser and Pilgt, 1988; Walmesley and Lewis, 1993; Brookfield, 1969; Downs, 1970; Downs and Stea, 1973). The centrality of the environmental context within which behaviour is observed is also recognised (Lewin, 1951; Krupat, 1985). In utilising the concept it is important to avoid being environmentally deterministic. It is important to recognise that humans are goal directed animals that influence the environment and are influenced by the environment they are in (Craik, 1973; Stokols, 1977) (figure 1.1).

Figure 1.1 The Traffic Barrier Concept

STREET/ENVIRONMENTAL CONTEXT **Changing nature of traffic/street environment characterised by:** **1. Increase in traffic levels**
PERCEPTIONS OF THE ENVIRONMENT **Perception of increase in traffic levels characterised by:** **1. Increase in perceived crossing difficulty** **2. Reduction in perceived level of safety**
BEHAVIOURAL RESPONSE **Behavioural response mediated by perceptions of increase in traffic levels.** **Observable behavioural response characterised by:** **1. Increase in pedestrian delay** **2. Increase in use of pedestrian crossing facilities** **Unobservable behavioural response characterised by:** **1. Pedestrian deterrence and detours** **2. Lack of social contact**

The term severance (DTp/IHT, 1987) (see p. 4-5) refers to both physical and psychological effects of adverse traffic levels in general terms. For the traffic barrier concept to be used effectively it is important to recognise both that there are observable impediments to movement which result in behavioural change and that there are psychological impediments which may not result in observable behavioural change (Walmesley and Lewis, 1993). The literature on pedestrian behaviour and perceptions clearly indicates that variables relating to physical and psychological aspects of the traffic barrier can be identified (chapter 2).

Traffic barriers are set in the context of the trade-off which exists between pedestrian mobility and safety, a trade-off which is influenced directly by the impact of traffic conditions on pedestrian crossing behaviour and their perceptions of the street. This trade-off between pedestrian mobility and safety, is of direct relevance to the implementation of traffic calming and other types of traffic management schemes on more heavily trafficked roads.

The goals of traffic calming may be stated as:

1) to improve road safety;

2) to reclaim space for pedestrian and non-traffic activities;

3) to improve pedestrian mobility and reduce traffic barriers;

4) to promote greater security, in particular among residents, pedestrians and cyclists; and

5) to create an improved environment (Pharoah and Russell, 1989, P5).

Given these goals, there are contradictions within the policy framework, as Russell and Pharoah indicate:

> "More complex main road schemes inevitably bring contradictions with other traffic calming and wider policy objectives. The reduction of barrier effects to pedestrian movement in shopping street schemes is an obvious example. If pedestrians feel more secure and therefore cross the road more frequently, pedestrian casualties may not decrease and could even increase, although a reduction in their severity would still be expected. In situations such as these priorities and expectations need to be clearly established" (Russell and Pharoah, 1990, P8).

Studies of the traffic barrier and attempts to measure its effects must therefore address the trade-off between pedestrian mobility and safety.

1.2.3 Measurement of barrier effects

Any operational definition of the traffic barrier and its effects needs to go beyond merely referring to physical and psychological factors in general terms. Factors need to be identified which characterise the very nature of barrier effects. In order to do this it is important to identify measures other than pedestrian delay. The latter has "often been considered as a proxy for other aspects of the pedestrians' environment such as intimidation, worry or apprehension, danger and impatience" (DTp/IHT, 1987, P75) and involves assessing the different times taken by those crossing the road in deciding whether to cross.

Operationalisation of the traffic barrier then will involve measurement of observable behavioural changes resulting from changes in traffic speed and flow conditions. These behavioural responses are then subject to variation according to factors including age, health and walking situation (i.e. accompaniment) (figure 1.1), as identified in the research.

Buchanan (1963) and Goldschmidt (1977) suggested a method for evaluating the environmental capacity of streets based primarily on pedestrian delay. Studies of the traffic barrier undertaken elsewhere, information on which in English translations is limited, have also relied principally on delays experienced by pedestrians (SNRA, 1981; Danish Road Directorate, 1980). The key weakness of delay measures, treated in isolation, is that they do not refer to the deterrence of road crossings, that is, to those pedestrians who do not cross. Delay measures are consequently inadequate as a measure of barrier effects. Research has suggested that a combination of methods based on observation of a number of aspects of behaviour as well as interviews enables the effects of the traffic barrier to be more adequately assessed, rather than relying on pedestrian delay. Information on these studies though is currently limited and only available in short English summaries (Herrstedt, 1981; Norwegian Institute of Urban Regional Research, no date; Nordisk Vegteknisk Forbund, 1984). For a discussion on the other pedestrian behavioural measures used in behavioural research the reader is referred chapter 2.

Similarly, the reliance on pedestrian casualty data, to prove that a pedestrian safety problem exists, is not helpful (see p. 22-24). Opportunities, to improve conditions for pedestrians and reduce the traffic barrier effect, are often missed if the decision-making process is geared towards the use of accident statistics for the identification of priorities (blackspots) for treatment (Silcock and Smyth, 1985; Watt, 1987).

1.3 THE IMPORTANCE OF THE TRAFFIC BARRIER CONCEPT FOR POLICY AND PRACTICE

Recently revived interest in pedestrian road safety (DTp, 1989b) has been further marked by the U.K government's target to reduce road casualties by one-third by the year 2000 (DTp, 1987a). The elderly and young who account for substantial numbers of pedestrian casualties have been identified and targeted (DTp, 1990a; 1991b). Traffic calming has been widely embraced to help in attaining this target. Guidelines on road humps and the introduction of 20 MPH zones have been published (Scottish Office, 1991; DTp, 1990b). Speed management has found an increasing role in the government's strategy to cut traffic speeds in order to reduce fatalities of pedestrians and other road users. Highway authorities, in England and Wales, now have the power to set their own speed limits, on local and principal roads, without requiring consent from the Secretary of State for Transport (DTp, 1992b; 1993). The use of video surveillance cameras, on main roads, has also been advocated and is being employed as a successful method by which drivers can be deterred from travelling at excessive speeds (Local Transport Today, 1993). No criteria have yet been explicitly stated in any of these governmental publications by which the effects of remedial measures, such as traffic calming schemes, could be assessed in terms of their impact on pedestrian movement and behaviour.

The lack of criteria for assessing the impact of schemes on pedestrians is especially noticeable in relation to the development of "Red Routes" and bus priority schemes which involve the intensification of parking and waiting restrictions for vehicles along designated routes. This omission is despite a commitment to give consideration to the reasonable needs of the disabled, pedestrians, and cyclists (DTp, 1989a; Collis, 1991; Bates and Jory, 1991; Wood and Smith, 1992).

1.3.1 Assessing conditions for pedestrians in practice

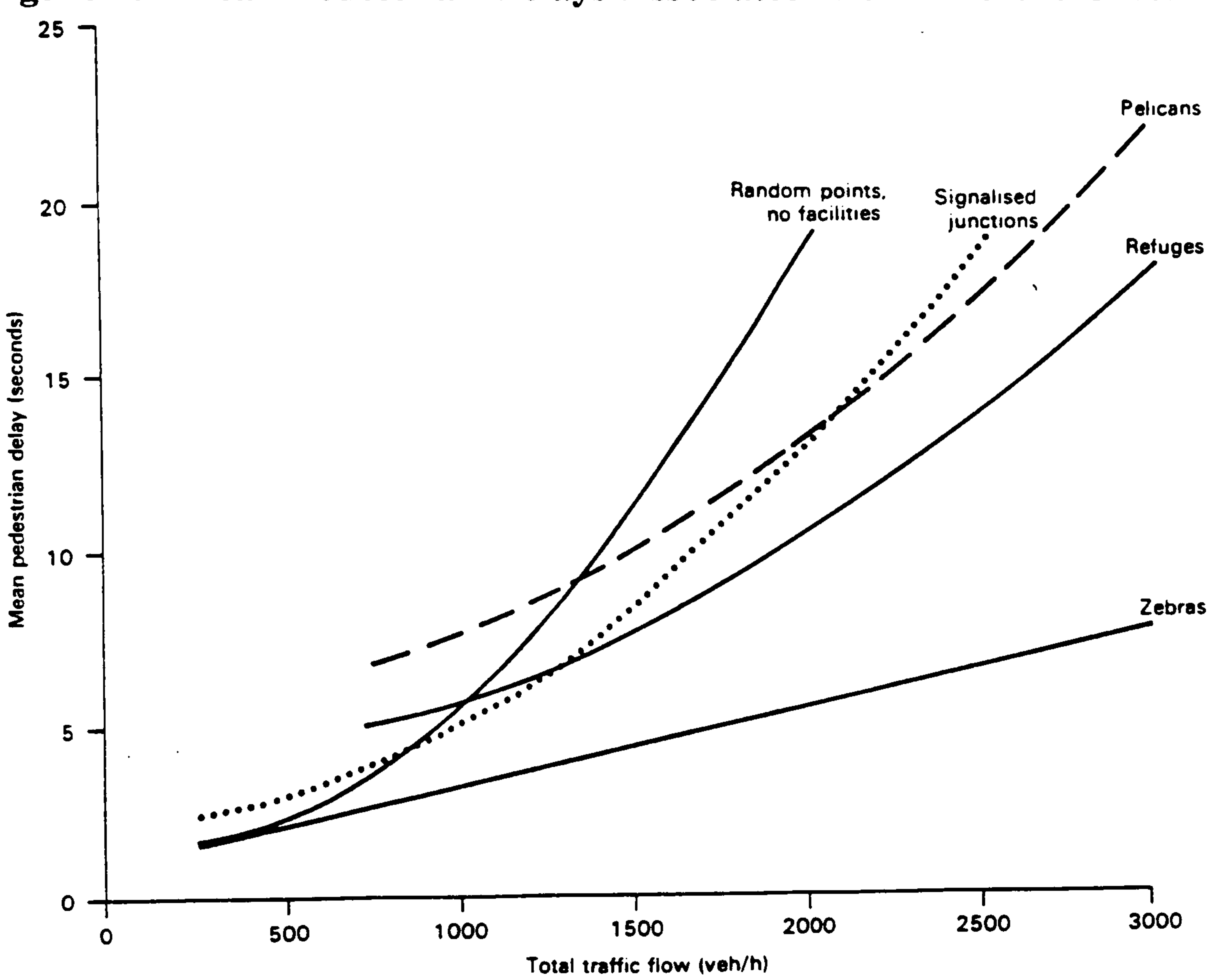
Measures used in practice to assess conditions for pedestrians rely on the use of pedestrian delay and flow criteria in relation to the provision of crossing facilities, in order to assess pedestrian mobility. Accident statistics are used to measure safety standards.

In the absence of data about pedestrian behaviour and in particular about pedestrian responses to changing traffic conditions, pedestrian delay has been considered as a proxy for other aspects of the pedestrians' environment such as intimidation, danger and stress (DTp/IHT, 1987, P75). Pedestrian delay here refers to the proportion of pedestrians delayed and the mean length of that delay. Changes in journey time are seen as the principal measurement by which the impact of traffic on pedestrian movement and crossing behaviour can be assessed:

> "Once the general pattern of pedestrian and cyclist movements has been established the next step is to assess the length of diversion people will have to make under each option" (DTp, 1983, section 9.3.1).

For measuring pedestrian delays, approximate correlations between traffic flows and delay for different types of crossing facility have been developed (figure 1.2) (Goldschmidt, 1977). This work suggests that given a certain hourly traffic flow, it is possible to suggest pedestrian crossing arrangements which would be most likely to minimise pedestrian delay. The use of delay measures in isolation, as has been noted, is unsatisfactory. Firstly the deterrence of road crossings is ignored, that is those who choose not to cross at all, a phenomenon which is associated with the traffic barrier. Secondly, where delay measures are restricted to kerb delays, this approach underestimates delays associated with trip diversions, resulting from longer trips.

Figure 1.2 Mean Pedestrian Delays Associated with Different Crossing Facilities



(Source: Goldschmidt, 1977)

An alternative measure of the need for pedestrian crossing facilities relates to measures of pedestrian concentration. However the use of flow criteria (measures of pedestrian concentration), or levels of service are not mentioned in current advice for footways or footpaths. Recommendations for footways are defined in terms of their absolute capacity (DTp/IHT, 1987). This is perhaps surprising given the stated commitment to making the best use of existing footways and footpaths (DTp/IHT, 1987, P193). Flow criteria are used however in relation to the provision of pedestrian crossing facilities. The Department of Transport recommends the use of empirically based criteria in order to assess whether the volume of potential conflicts between pedestrians and vehicles is sufficiently high to justify a formal crossing. The criteria are based on a calculation of PV^2 where:

P = the pedestrian flow (pedestrians/hour) across a 100 metre length of road centred on the proposed crossing site, and

V = the number of vehicles in both directions (vehicles/hour).

The PV^2 value is usually based on the 4 busiest hours of the day and a formal crossing is normally justified where the calculated value of PV^2 is greater than 1×10^8. For crossing facilities divided by a central refuge this figure is increased to 2×10^8. Figure 1.3 shows the type of crossing recommended for the different combinations of vehicle and pedestrian flows (DTp, 1979). At locations where appropriate values of PV^2 are not achieved a formal crossing may still be justified:

> "where there is substantial community severance; at sites adjacent to community centres, homes for elderly, infirm or blind, hospitals or clinics, outside school entrances and in busy shopping areas; where there are significant numbers of heavy vehicles (300 vehicles/hour during the 4 busiest hours); where there are pronounced seasonal variations in the number of pedestrians" (DTp/IHT, 1987, P195-196; DTp, 1987b; 1987c).

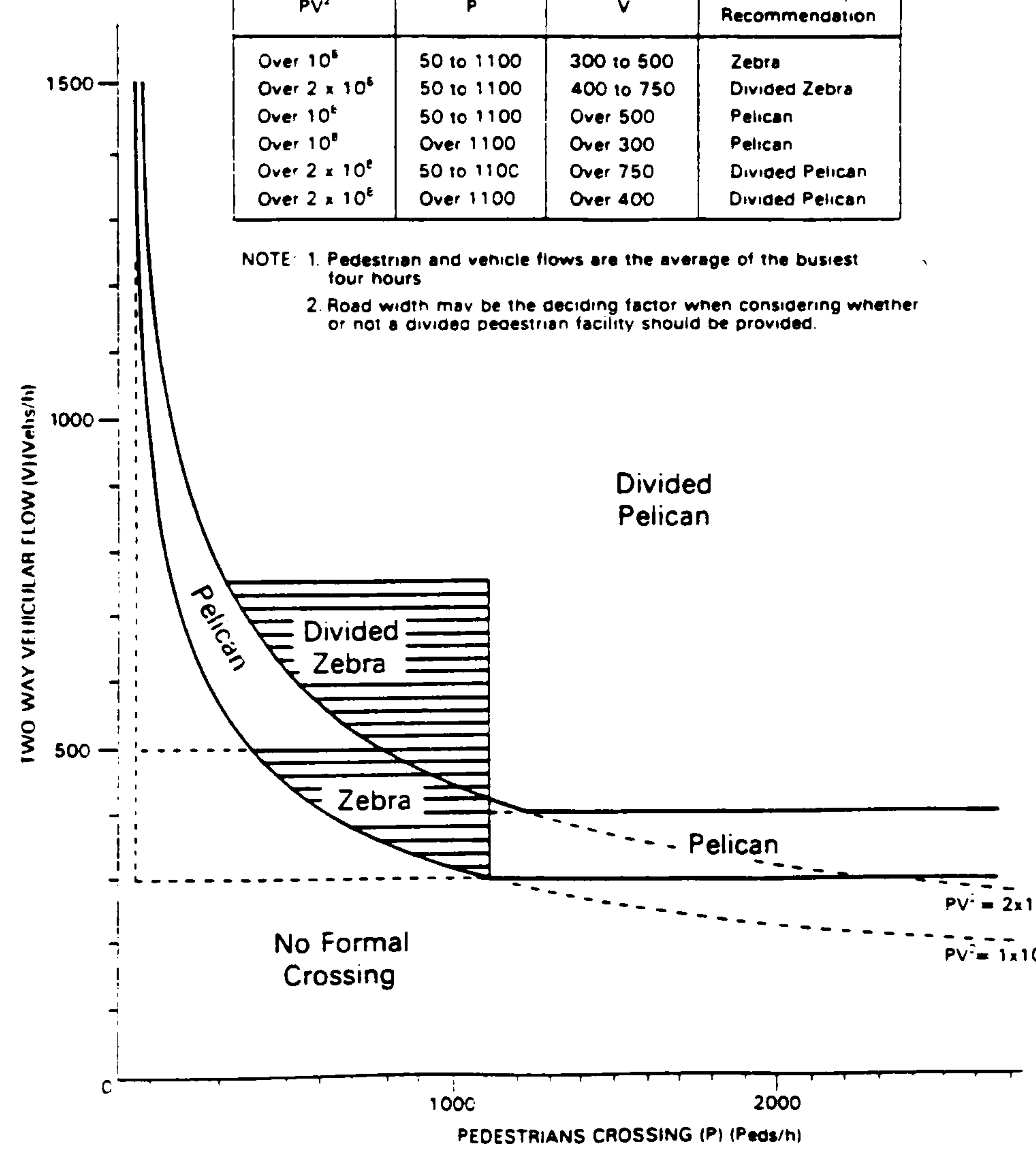
The PV^2 formula has been criticised. The setting of the relationship of P and V at PV^2 and at a threshold of 10^8 seems to have been largely arbitrary. The criteria are also based on actual pedestrian crossing flows and therefore reflect suppressed demand, where barrier effects exist, rather than actual demand (Davis and Donnellan, 1989), thus neglecting those who experience the traffic barrier and who are deterred from crossing the road. Whatever view is taken of the PV^2 formula it does not deal with all aspects of severance and is not a measure of the traffic barrier effect.

Figure 1.3 Suggested Warrants for Formal Crossing Facilities, based on PV^2.

PV^2	P	V	Preliminary Recommendation
Over 10^8	50 to 1100	300 to 500	Zebra
Over 2×10^8	50 to 1100	400 to 750	Divided Zebra
Over 10^8	50 to 1100	Over 500	Pelican
Over 10^8	Over 1100	Over 300	Pelican
Over 2×10^8	50 to 1100	Over 750	Divided Pelican
Over 2×10^8	Over 1100	Over 400	Divided Pelican

NOTE: 1. Pedestrian and vehicle flows are the average of the busiest four hours

2. Road width may be the deciding factor when considering whether or not a divided pedestrian facility should be provided.



(Source: DTp, 1979; 1987)

Accident statistics are widely used in practice to prove that a pedestrian safety problem exists and to justify the provision of crossing facilities and safety measures. This approach, however, is flawed: a road may be perceived to be unsafe without high recorded levels of accidents. It has been argued that this helps to promote street environments where pedestrians find it hard to cross the road and which are perceived as dangerous places. Adams has noted that:

> "Official concern for pedestrian safety often exacerbates the severing effect of traffic. Safety problems are defined in terms of injury accident statistics; if a road does not have an exceptionally high accident rate it is not officially dangerous" (Adams, 1985, P174).

The primacy of accident data in defining a road safety problem has also been called into question by recent research. It has been suggested that accident data, particularly pedestrian casualty data, may actually under-represent the extent of the safety problem for pedestrians. Studies suggest that only between 73% and 85% of pedestrian casualties are actually reported (Bull and Roberts, 1973; Hobbs, Gratten and Hobbs, 1979; Tunbridge and Everest, 1988).

Other studies have highlighted two effects - regression to mean and accident migration - the existence of which could undermine the claims made for the efficacy of particular road safety measures. Hauer (1980) and Abbess, Jarrett and Wright (1981) have demonstrated that studies of accident blackspots using accident data before and after the introduction of engineering measures have shown a bias: the regression to mean effect. This relates to the random element existing within the distribution of accidents during any given time period. As a result there is a high probability that a section of road experiencing an exceptionally large number of accidents in a given time period - the definition of an accident blackspot - would have a lower number in a succeeding time period without any treatment at all. Indeed Hauer has demonstrated that in certain circumstances it is possible for the bias in before-and-after studies to account for all the effect claimed for a particular treatment. A phenomenon known as accident migration has also been identified by Ebbecke and Shuster (1977) and Wright and Boyle (1984). These studies indicated a tendency for accidents to decrease at places where the site had been treated and for accidents to increase in the immediate vicinity of the treatment: blackspots in the case of Wright and Boyle, and the conversion of intersections from 2-way to 4-way stop-sign control in the case of Ebbecke and Shuster. This prompted Ebbecke and Shuster to state:

> "The total area accidents are not being reduced they are just being rearranged" (Ebbecke and Shuster, 1977).

More recently Hauer (1992) has warned of the need to be wary of claims made for road safety management measures. In a study Hauer highlights the fact that while fatalities from injuries sustained in motor vehicle accidents has declined, the number of injuries is still increasing. The study concludes that the decline in fatalities may be the result of improved medical treatment and not the successful implementation of road safety measures.

Doubts also persist over traffic conflict studies (the observation and categorisation of hazardous manoeuvres) in terms of their validity (Engel, 1985; Malaterre and Mahlrad, 1980). The subjective nature of how a conflict is defined (Taylor and Young, 1988) and the fact that there is a lack of a clear relationship between accidents and conflicts (Bryant, 1973; Thorson and Glennon, 1975; Glennon, 1977; Oppe, 1977; Williams, 1980, 1981) would seem to suggest that conflict studies are of little value in assessing pedestrian crossing behaviour and the barrier effects of traffic. Nonetheless there could be relationships between conflicts and perceptions of safety which in turn affect crossing behaviour. Measurement problems appear insuperable however.

1.4 CONCLUSION

Existing approaches aimed at assessing the quality of pedestrian environments in terms of the impact of motorised traffic on pedestrian behaviour have failed to grapple successfully with pedestrian behavioural change. Approaches have been found to be imprecise in that they deal implicitly with recognition of the need to quantify and define the effects of traffic on pedestrian behaviour, or omit key issues such as addressing the linkages between environment and behaviour. There is clearly a need for a different framework which can assess the effects of traffic on pedestrian behaviour.

The traffic barrier concept is then an important consideration for policy and practice. Current methods of assessment - pedestrian delay and the use of flow criteria - have been shown to be flawed in terms of the ability to adequately assess the impact of traffic on pedestrian behaviour and movement. The use of accident data has also been criticised. In particular it has been noted that all these methods under-estimate the impact of traffic on pedestrian behaviour. The traffic barrier concept seeks to encompass and assess the constraints placed on pedestrian behaviour and movement by explicitly recognising that the traffic environment, as mediated by perceptions, can determine a behavioural response or change. It is also noted that observed behaviour is but one response that might be the outcome, affecting a pedestrian journey, as a result of changing traffic conditions (p7-10).

Existing methodologies ignore this possibility and as a consequence underestimate the impact of traffic.

1.5 AIMS OF THE RESEARCH

This study then, is concerned with the examination of the relationships between pedestrian crossing behaviour and traffic conditions through the study of traffic barrier effects experienced by pedestrians. The objectives of the thesis are to:

1) improve understanding of the relationships between pedestrian crossing behaviour, and changing traffic conditions through the day;

2) improve understanding of the traffic barrier effect, and of the implications of the barrier effect for pedestrian behaviour. This is explored in terms of the:

i) development of specific techniques for measuring pedestrian crossing behaviour, such as walking situation, pedestrian delays and acceptance gaps and the use made of parked cars when crossing;

ii) examine differences in pedestrian crossing behaviour between different age groups in terms of the specific measures of pedestrian behaviour;

iii) assess changes in pedestrian movement patterns generally, using a measure called the crossing ratio expressed as the proportions of pedestrians crossing as a percentage of total flow on the respective pavements; and

iv) explore pedestrians' perceptions of danger, risk and inconvenience which can suppress pedestrian crossing activity and lead to changes in pedestrian behaviour;

3) highlight the implications of this study, in terms of the assessment of the impact of traffic on pedestrian behaviour and movement, for policy makers and practitioners.

1.6 THE STRUCTURE OF THE THESIS

A review of the literature (chapter 2) highlights the dearth of studies on pedestrian behaviour and safety and the lack of studies which address the effects of changing traffic conditions on pedestrian behaviour. This is followed by a description of the methodology developed in the two stages of the research and the changes made following the first stage study (chapter 3). Findings from both the first and second stages of the video and questionnaire surveys are analysed and summarised with reference to the barrier effect and the implications for pedestrian crossing behaviour on radial routes (chapter 4 and chapter 5). These findings are then supplemented by a discussion and analysis of results from personal in-depth interviews which focus on pedestrian experiences and perceptions whilst avoiding the constraints of the set format questionnaire surveys (chapter 6). The findings are then discussed in terms of the implications for practice in the redesigning of streets and the implementation of traffic calming schemes and traffic management measures generally. Future research issues stemming from this work are suggested along with recommendations for current practice and policy (chapter 7).

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

In the background to this study, highlighted in chapter 1, it has been suggested that there is evidence of behaviour changing as a result of changes in the street and traffic environment. The general concept of behavioural adaptation was introduced along with the concept and definition of the traffic barrier. The traffic barrier involves specifically the phenomenon of pedestrian behavioural modification in response to changes in the traffic and street environment. There are problems of measurement associated with the operationalisation of the term traffic barrier. This review of the literature addresses aspects of pedestrian behavioural research which have important implications for the study of traffic barriers and seeks to identify suitable variables which could serve as suitable partial or proxy measures of the traffic barrier: measures of observable change in pedestrian behaviour resulting from changes in traffic conditions. The purpose of this review of the literature is to assess how far previous research has directly addressed these issues and in what ways existing research can be used to inform a study of traffic barriers.

The review of literature in this chapter highlights areas of research which have been the primary focus of attention. Little has been done to directly assess the impact of changing traffic conditions on pedestrian crossing behaviour and movement. However there is a range of research which refers to relevant aspects of pedestrian behaviour. The research identified is discussed under five headings. These are:

1) Studies of pedestrian road casualty studies and the safety of crossing facilities and countermeasures;

2) Studies of predicting pedestrian flows from different land uses and the development of predictive equations;

3) Studies of the level of service and space standards;

4) Studies of pedestrian crossing behaviour at random locations and at crossing facilities; and

5) Pedestrian attitude studies and studies of the use made of the street.

2.2 PEDESTRIAN ROAD CASUALTY STUDIES AND THE SAFETY OF CROSSING FACILITIES AND COUNTERMEASURES

The first group of studies relevant to research on pedestrian behaviour relate to studies of accident and casualty data. Accident and casualty data have been used to describe trends in pedestrian safety. The aim of this research has been either directly or indirectly to reduce those accidents (Firth, 1982, P43). These studies have focused on factors which account for variations in accidents and casualties and systematic effects such as time of day, weather, age and sex. Concepts of exposure and risk have also been developed to help understand why certain groups of pedestrians are more vulnerable. Pedestrian casualty studies (and studies of exposure to risk) have highlighted the vulnerability of the young and elderly (for references see below). Many studies have also been conducted into the safety of pedestrian crossing facilities, especially through comparisons between Pelican and Zebra crossing facilities. More recently, research has focused on countermeasures and the impact of traffic calming on pedestrian behaviour and safety (for references see below). The focus has remained however on the use of accident data to assess the impact of such interventions in the traffic environment. This section reviews:

1) Pedestrian road casualty studies;

2) Studies of pedestrian crossing facilities focusing particularly on Zebra and Pelican crossings and central refuges;

3) Countermeasures, pedestrianisation and traffic calming and their impact on safety.

2.2.1 Pedestrian road casualty studies

Wade, Foot and Chapman (1982) analysed pedestrian casualty data by time of day and day of week using data from 1978 for Great Britain and compared the resulting casualty patterns for both adults and children. They found, that during all weekdays, there are three peaks in the pattern of child pedestrian accidents. These were at the hours commencing 8 a.m., 12 noon (the smallest peak), and 4 p.m. (the largest peak). A similar pattern has been identified by Grayson (1975a) and King et al (1987). For adults, they found that the pattern yields four peaks; occurring at 8 a.m., 12 noon, 4 p.m. Fridays and 5 p.m. on Mondays to Thursdays and at 11 p.m.. In addition to this, adults were found to sustain casualties earlier in the morning than children. At weekends, accidents involving children were found to be distributed fairly evenly throughout the day from 9 a.m. until 8 p.m., peaking in the early afternoon on Saturdays, and a little later on Sundays. The pattern was found to be similar for adults although rather than tailing away at 8 p.m. the number of casualties increases again peaking at 11 p.m.. (Wade, Foot and Chapman, 1982, P238-239).

Wade, Foot and Chapman advanced several explanations for these daily and weekly fluctuations. These were firstly, that the large weekday late afternoon peak for children was a result of hazards encountered on the journey home from school, while playing and running errands; and secondly, that in the case of the peak in adult pedestrian casualties, this was due to activity levels, associated with journeys home, being higher as theatres and pubs close in the evening and the alcohol-affected state of pedestrians at this time of day. Harris and Christie (1954), after taking changes in vehicle and pedestrian flow into account, found that darkness has the effect of multiplying the adult pedestrian casualty rate by 3, and the adult pedestrian fatality rate by 6 (also quoted in Smeed, 1968). Yaksich (1959) noted that the absolute distribution of accidents according to time of day was closely related to the vehicle and pedestrian traffic density.

Seasonal variations also produced systematic fluctuations. Bennett and Marland (1978) found that accidents to children under 10 were more common in summer than in winter. A similar pattern was also found to exist in Sweden, with higher accident rates in May and August than in winter (Sandels, 1975). Biehl, Older and Griep (1969) also endorse this pattern. Smeed (1968; 1977) studied the effects of darkness on pedestrian accidents by using "British Summer Time". The study found that the number of pedestrian casualties was halved for the hours which changed from dark to light and doubled in those which changed from light to dark. Singer (1963) found that in the U.S.A, 60% of pedestrian fatalities occurred during the hours of darkness. Hillman (1988) has indicated that the transfer of one hour of daylight from the morning to the evening throughout the year could help to reduce pedestrian road casualties.

Child pedestrian accidents, up to the age of 10, have been found to occur within a short distance of their homes, on predominantly residential streets (Grayson, 1975; Preston, 1972; Read, Bradley, Morison, Lewall and Clarke, 1963; Transport and Road Research Laboratory, 1977; Wade, Chapman, and Foot, 1979, 1981; Lawson, 1990). In the case of pedestrian accidents involving older children, these occur further away from home and tend to be located on more major roads (Grayson, 1975; Preston, 1972; Tight, 1987; 1989). This pattern of child pedestrian accidents has recently been highlighted by the Department of Transport (1990b). Studies have also identified accompaniment and supervision as important factors in relation to child pedestrian casualties. Grayson (1975a) found that 44% of children were alone at the time of the accident, while Tyler and Walker (1971) found that 32% of the 0-4 age group were involved in an accident when alone.

Preston (1972) found a strong relationship with overcrowded living conditions (high density) and child pedestrian accidents. Similarly, Backett and Johnston (1959) found that a greater proportion of accident vulnerable younger children were found among families in overcrowded living conditions. While Read et al (1963) in a later study found that children involved in accidents were more likely to come from flats in the more densely populated areas of the city centre. In both these studies it was also found that the mothers of the children involved in accidents had more commitments outside the home and were also concerned with employment outside the home. These findings are in agreement with work carried out by Ekstrom, Gastrin and Quist (1966) and suggest the increased vulnerability of the child when living in such circumstances (Sheehy, 1982, P215).

Other work suggests that children figure highly in the accident statistics due to a poor level of road sense (Scottish Office, 1989b). Several other studies prefer to argue from a developmental perspective and refer to physiological and mental limitations (Sandels, 1975; Deutsch, 1964; Piaget and Inhelder, 1956; Shantz, 1975; Cattell and Lewis, 1975). Other authors have explained the vulnerability of children in terms of individual characteristics. These studies either focus on what is an "accident prone" personality or on individual development (Shaw and Sichel, 1971; Manheimer and Mellinger, 1967).

Studies have also found that the elderly feature more in road accident data as fatalities and as the seriously injured. Yaksich (1959, 1960, 1964) stated in his analyses of pedestrian accidents that the high number of fatalities involving those in the over 65 age group were due, in part, to their weaker physical condition. Yaksich (1965) notes that for the elderly the following factors produced an increased accident risk: impaired hearing and vision; less accurate depth of perception; decreased lateral field of vision; slow perception and reactions; and decreased capacity for learning. Garwood and Moore (1962) and Smeed (1968) also noted that the elderly pedestrian has the highest fatality rate, followed by young children. Sabey (1989) and the Department of Transport (1991b), in reviewing the nature and the scope of the pedestrian accident problem, note that the elderly feature more amongst casualties either killed or seriously injured. Difficulty in walking, poor eyesight or hearing is seen to be a partial cause of an accident to this age group (Sabey, 1989, P9; DTp, 1991b, P3). Recent work by Ward et al (1994) has indicated that it is not just the older and younger pedestrians who are at risk but also young adults, particularly male.

Several studies have identified alcohol as a significant factor in adult pedestrian accidents (Clayton, 1973; Clayton, Booth and McCarthy, 1977; Clark, 1971; Everest, 1992). This may be a contributory factor in terms of the late evening peak in adult pedestrian casualties (Wade, Foot and Chapman, 1982, P239). Other studies of pedestrian casualties have linked ethnic minorities with traffic accidents. Lee (1986), in a study in Rochdale found that the number of accidents among those aged under 16, was twice as high for those of Asian origin, although no disaggregations were undertaken by road user type. Lawson (1991) also identified the high incidence of pedestrian casualties among those of Asian origin. The area types used in these studies were predominantly inner-city areas which experienced high traffic levels.

A strong causal relationship between parked cars and child pedestrian accidents, principally due to masking has been identified. This is closely linked to the height of the child (King et al, 1987; Scottish Office, 1989; Lawson, 1990; Carsten et al, 1989). Recent work by Davies and Winnett (1993) has indicated that parked or stationary vehicles are contributory factors in accidents involving pedestrians. Nevertheless pedestrian casualty research has failed to date to identify the role of parked vehicles in relation to pedestrian crossing behaviour.

2.2.2 Pedestrian crossing facilities: Zebra and Pelican crossings

In 1961, the then Road Research Laboratory found that high accident rates existed in the vicinity of Zebra crossings (Road Research Laboratory, 1965, P13). Pfundt (1964) found similar results in studies of sites in Cologne, Germany. Mackie (1962) showed in a study of 21 Zebra crossings in the London area, that by comparing the pedestrian flow with pedestrian accidents, the risk of an accident on the crossing is only half that of an accident off the crossing. Weaver (1968) found that the risk of an accident when a pedestrian was within 50 yards of a crossing was 5 times greater than actually on the crossing itself. Moore and Older (1965) though point out that Zebra crossings are located at dangerous sites which would imply increased risk in the stretch of road where the crossing is located.

Mackie and Older (1965), in a study of pedestrian risk on roads in London's inner suburbs, found that the risk of a pedestrian becoming a casualty was lowest on Zebra and Pelican crossings, but highest within 50 yards of them, for pedestrians of all age and sex groups. Also, pedestrian risk was found to be higher for all age and sex groups, whether on or off crossings, if the sections of road were near to road junctions. Evidence from the study also suggests that on Zebra crossings, within 20 yards of a junction, as pedestrian numbers (and pedestrian density) increase the risk of injury decreased. The study also found that within 50 yards of a Zebra crossing and within 20 yards of a junction, increases in traffic volume and turning movements were found to increase levels of risk. Grayson (1987) compared this study with one conducted in 1983 and concluded that the pattern of risk on the roads in West London was substantially the same as it was 20 years earlier. However, in 1983, vehicle flows on the roads themselves had no consistent effect on pedestrian risk or on the usage of pedestrian crossings. This is in spite of the fact that vehicle flow was found to have increased by 35%, while pedestrian casualties decreased by 34%.

Jacobs and Wilson (1967), in a study of pedestrian risk when crossing busy roads in the shopping areas of 4 towns (Cheltenham, Worcester, Rugby, Bath), reported similar findings to those of the Mackie and Older study. Pedestrian risk was found to be lowest on crossings, but near junctions within 50 yards of a crossing, risk was highest. In the vicinity of road junctions, pedestrian risk, on and off crossings, was found to be higher when the sections of road were in the vicinity of a junction.

Rayner (1975) studied the before and after personal injury accidents at sites where Zebra crossings have been converted to Pelican crossings. Rayner concluded from the results of this preliminary study that a safety benefit could not yet be ascribed to the conversion from Zebra to Pelican crossings, although the results suggested that pedestrian accidents on a crossing generally fell following conversion: a reduction of 28% at 30 sites where the crossing was moved less than 15 metres or not at all, and at 8 sites moved over 15 metres, a reduction of 52%. For sites not relocated more than 15 metres, pedestrian accidents away from the crossing increased: 73% within 20 metres of the crossing but not on the crossing and at 20 to 50 metres from the crossing by 357%. Bruce and Skelton (1977), in a survey based on Merseyside, found a decrease of 21% in accidents after conversion, while a more recent study in South Yorkshire indicates a 23% reduction across 55 sites (Bagley and Fletcher, 1985).

Landles (1983) in a study of the effects of installing Zebra crossings at sites where previously there was nothing, found that a Zebra crossing achieved significant reductions in accidents only if the accident rate prior to installation was at or above the average (2-3 a year). He found however that there was also a 50% increase in the number of pedestrian accidents when Zebras were installed, where before there had been no definable problem. The Dutch Institute for Road Safety Research (SWOV, 1975) in an international comparison of the effect of various crossing facilities on pedestrian safety, suggested that the siting of crossings may be more important than their number.

Jacobs (1966) showed that guardrails on roads where Zebra crossings were located every 100 yards reduced the percentage of pedestrians crossing the road between Zebras from 19% to 7% (the latter mainly using gaps in the railings or crossing at junctions). Heraty (1986) comments that the research indicates that pedestrians should be prevented from crossing in the vicinity of a crossing, and channelled onto the crossing itself. Stewart (1988) in a study of the effect of pedestrian guardrails suggested that they were detrimental to child pedestrian safety due to associated masking effects. Using data from a before and after study in London, looking at the effects of erecting pedestrian guard rails on accidents, Stewart noted that adult casualties showed a reduction of 33% while child pedestrian casualties showed a 90% increase. Data from another report by the London Accident Analysis Unit (Lalani, 1975) including data from 40 Zebra crossings, of which 30 had guardrails and 10 had none, also showed that child pedestrian casualties were 3 times as frequent at sites with guard rails than at those without.

Trials conducted into the extension of the green phase at Pelican crossings for pedestrians of up to 4 seconds, found that pedestrians were encouraged to use the crossing rather than the area 50 metres either side of the crossing. Following implementation of this, pedestrian accidents were found to have significantly decreased in London (Landles (1982) and Leicestershire (Pye, 1983).

Inwood and Grayson (1979) compared the safety of pedestrian crossings by examining the traffic flow and accident characteristics of 140 crossings throughout the country (51 Zebra crossings without central refuges, 33 Zebras with central refuges, and 56 Pelicans without refuges). Evidence suggested that there were no differences between pedestrian accident rates on Pelican and Zebra crossings. Data indicated that Pelicans have a lower total accident rate than Zebras, and that this is mainly due to lower vehicle accident rates at Pelicans. Interestingly, observations made at the time of the traffic counts showed that parking and overtaking in the vicinity of crossings occurred more frequently at Pelicans than at Zebras.

Hunt and Griffiths (1989) analysed injury accidents at 243 pedestrian crossings (132 Pelican and 111 Zebra) in Hertfordshire, over a 5 year period. The study derived relationships between accident frequency and appropriate explanatory variables, with the objective of developing equations which could be used to assist in preparing criteria for the choice of an appropriate crossing facility. The study found that the overall accident rates per year were 0.36, 0.39 and 0.26 accidents for Zebra, fixed time Pelicans and vehicle actuated Pelicans respectively. The overall predicted mean accident rate was 34% lower at Pelican crossings compared to Zebra crossings operated under the same flow conditions. No significant difference was found between vehicle actuated and fixed time Pelican crossings, resulting in no conclusive evidence to suggest that vehicle actuation reduces accident frequency at Pelican crossings. The inclusion of pedestrian and vehicle count data improved the fit for the models for both Zebra and Pelican crossings, while the inclusion of road width provided a significant improvement of fit in the case of Zebra crossings only. Locational and environmental variables including layout (non-refuged, refuged), traffic direction, guard rails, site type, proximity of public house, and proximity of junction produced no significant improvement in the fit of the Zebra crossing model. For Pelicans, junction proximity and guard rails improved the fit significantly, although in the case of guard rails, this may be due to them being installed at some high accident rate sites during the 5 year period as an ameliorative measure. For both Pelican and Zebra crossings, an increase in either pedestrian and vehicle flow is associated with an increase in the predicted annual accident frequency.

More recently, the Transport and Road Research Laboratory undertook a programme directed towards the revision of criteria for the installation of pedestrian crossings. As part of this, work was commissioned to carry out a study to derive models to predict pedestrian flows and accident frequencies at pedestrian crossing facilities (Daly, McGrath and Emst, 1991). A reduction of 18% in the total number of accidents, over a 3 year period, was recorded following the introduction of a crossing facility (877 to 736 accidents). From the data, it is suggested in the report that the introduction of crossing facilities had a greater impact on accident levels in adverse conditions: accidents in the dark were reduced by 28% (281 to 203) compared to a 14% reduction in light conditions (616 to 532); wet weather accidents also decreased (from 317 to 247), a 22% reduction compared with a 15% reduction (from 572 to 486) in dry conditions. Analysis of pedestrian flow data revealed a tendency for pedestrian crossing activity to decrease following installation of a crossing.

The best fitting accident frequency model for Zebra crossing sites included only vehicle flow, and was not a function of pedestrian flow. For Pelican crossing sites the best fitting accident model included vehicle flow, pedestrian flow, and town size. The variable town size indicates that as town size increased, so did the accident frequency. For no crossing facility sites only, vehicle flow and distance from the nearest junction were found to be significant in the model. The model revealed that as distance from the junction increased the accident rate was reduced.

The study also devised models for pedestrian casualties on and off crossings. Problems were encountered however, in that the data required further disaggregation resulting in a smaller data set, making the model fits more problematic. Another complication was encountered with the requirement to split the pedestrian crossing flow data into those on and off the crossing. Information on the flow split was not available from the historic local authority data.

For the Zebra crossing model, for casualties on the crossing, the variables public house presence and location were significant. The presence of a public house was estimated to increase the casualty frequency some 5 times, while location in the South of England was also found to increase casualty frequency. For crossing casualties occurring off the crossing, land use and road width were significant variables. Shopping land use, as in other casualty studies, was found to increase casualty levels, whilst as road width increased the accident frequency was found to decrease. For Pelican crossings the on-crossing model included pedestrian flow and town size. Town size indicating increased risk with increases in the size of settlement. For off-crossing casualties, only land use was significant indicating that shopping land uses on average have higher casualty frequencies.

2.2.3 Countermeasures, traffic calming and pedestrianisation

Studies of the effectiveness of school crossing patrols have suggested that accident rates were higher at sites where no school crossing patrol warden was operating (resulting from the local authority being unable to fill the vacancy). The provision of patrols was advantageous, where criteria for their provision were met, and was an extremely safe method of getting children across the road (Boxall, 1988). Saunders (1989) provided data to support this. In Dorset, in 1987, 2 children were involved in road accidents whilst crossing under supervision and were slightly injured, compared to 29 accidents occurring to children on their way to or from school whilst using a Pelican or Zebra crossing.

Research into the effectiveness of refuges is minimal compared to that for other types of crossing facility. Thompson, Heydon and Charnley (1990) studied the effect of Nottinghamshire's pedestrian refuge scheme and found a net saving of 25 accidents per year. However, a statistically significant reduction was achieved at only 2 out 23 of the schemes. This has some irony attached to it given that residents felt that adult and child pedestrian safety had increased following the introduction of the refuges. Lalani (1977) produced similar evidence suggesting the provision of refuges increased pedestrian accidents but reduced vehicle accidents. Lalani concluded that refuges are provided for pedestrian convenience rather than safety, but added that this provision may be at the expense of pedestrian safety. Activity levels, however, were not studied and it is possible that increases in pedestrian accidents, following the introduction of refuges, may result from increased pedestrian activity at these locations.

The impact of traffic management systems on pedestrian casualty patterns have also been studied. Sumner, Burton and Baguley (1978), in a study of the impact of the first British trial of road humps on a public road (Cuddesdon Way, Oxford), found that following implementation, accidents went down from an average of 1.7 a year in the 3 years before implementation, to zero the year the humps were in existence; although the extent to which this reduction was due to reduced speeds and flows or both was not clear.

Dalby (1979) demonstrated the potential for reducing accidents on an area-wide basis. Dalby and Ward (1981) reported on a trial at Swindon where right turn movements into residential streets were banned; turning controls at a number of remaining intersections improved and 3 new pelican crossings installed. The project found that accidents were reduced by 10% on the study route with no evidence of a corresponding increase elsewhere. These findings resulted in the introduction of the Urban Safety Project aimed at developing environmental management systems for improving road safety and reducing accidents in parts of 5 towns: Bradford, Bristol, Nelson, Reading and Sheffield. Although not specifically pedestrian orientated, results have indicated that the largest benefits have been to more vulnerable road user groups. From the results it was found that pedestrians benefited, although in two of the towns (Nelson and Reading) the change has been small. Overall child pedestrians benefited the most (a reduction of 29% over the 5 towns) although the effect was variable between the towns (Mackie, Ward and Walker, 1988).

In the Netherlands, the Dutch Demonstration Projects involved area-wide traffic management schemes with the reclassification of the road network resulting in a rationalisation of the major traffic arteries away from predominantly residential areas, the implementation of 30 km/h zones, and the reconstruction of streets and public spaces using traffic calming measures and pedestrianisation. These have resulted in reductions in pedestrian casualties (and other vulnerable road users) especially in residential zones (Janssen, 1991; Vis, Dijkstra and Slop, 1992). Research into the effects of 69 counter measures (56 woonerven, 3 village woonerven, 4 shopping woonerven and 6 other infrastructural measures) has also shown their effectiveness in reducing accidents to pedestrians and cyclists (Kraay, 1986). However, changes in the mobility of pedestrians and cyclists could not be demonstrated. In Germany, the Area-Wide Traffic Restraint Project in 6 cities (Berlin, Mainz, Ingolstadt, Esslingen, Buxtehude, and Borgentreich) also involved the use of traffic calming, the introduction of 30km/h zones and pedestrian orientated measures aimed at reducing traffic flow and speed. These schemes resulted in favourable reductions in the number of pedestrian casualties, especially fatalities (Bowers, 1986; Kahrmann, 1985; Holzmann, 1985; Keller, 1986; Hass-Klau, 1986). The number of pedestrian accidents in Buxtehude, for example, declined by 20% (Kahrmann, 1985). French studies have also noted a reduction in the number and severity of accidents following the implementation of speed reducing measures. These studies have also indicated that a feeling of insecurity persists (Faure, 1992).

Similarly, environmental traffic management measures in Denmark have reduced the number of pedestrian casualties and their severity (Nielsen and Rassen, 1986; Engel and Krosgaard Thomsen, 1989). Results of an evaluation of over 600 traffic calming schemes in Denmark, by the Danish Council for Road Safety Research, indicate reductions in casualties of 45%, compared with a controlled sample of untreated roads over similar before and after periods (Danish Council for Road Safety Research, 1989). Results from the Danish "Three Village" studies, where traffic calming measures have been implemented on main traffic routes, also indicate substantial accident savings, although other objectives such as the reduction of barrier effects and the improvement of pedestrian mobility are also prominent in such schemes (Herrstedt, 1984; Pharoah and Russell, 1989).

More recently, a survey of current traffic calming practice in Britain, showed substantial reductions in the number of accidents after the implementation of traffic calming schemes (Hass-Klau, Nold, Bocker and Crampton, 1992). Initial findings, from a review of 20 mph zones in the U.K., suggest large reductions in accident numbers in traffic calmed zones, with accompanying reductions in severity (Hodge, 1992; Challis, 1992). Space sharing and pedestrianisation measures have also been shown to have a favourable accident reducing tendency. Halton Brow, Runcorn in Cheshire, which was developed along the lines of the Dutch Woonerven in which pedestrians and vehicles share the same space but where the roads have been designed to deliberately reduce speed, has had no road accidents involving personal injury after 10 years (Jenkins, 1975 and Jenks, 1979).

Pedestrianisation has also been shown to be an effective measure in the reduction of accidents involving pedestrians, although in itself not a safety measure. Dalby (1976) reports on one successful pedestrian/space sharing scheme in Queen Street, Oxford, where, in 1970, vehicle prohibition (except for buses) produced a reduction in the number of pedestrian accidents from 7, 2 years prior to its introduction to 1, 2 years after. Turner and Giannopoulus (1974), in a study of a ban on traffic (except buses and taxis) along a section of Oxford Street, London, found a 50% reduction in serious accidents, although slight accidents were found to increase by 13%. Nottinghamshire County Council (1976), in a study of pedestrianisation in the centre of Nottingham, reported a 60% reduction in accidents.

2.2.4 Conclusion

The existing literature on studies of pedestrian casualty data and the safety of crossing facilities and countermeasures has not been directly concerned with the study of traffic barrier effects. Studies seeking to address the impact of interventions in the traffic environment have focused on accident data analysis and have not sought to monitor pedestrian flow and movement patterns following the introduction of pedestrian crossing facilities or other countermeasures. Due to this failure, claims of accident savings are sometimes suspect. A more effective assessment of pedestrian crossing behaviour is required to enable policies to account for this.

The elderly and young feature most often as pedestrian casualties. Accompaniment, supervision and crossings from behind parked vehicles, have been identified as important factors in relation to child pedestrian casualties. This would indicate that age, walking situation and the use of parked cars in relation to the pedestrian crossing task are important factors to be considered in any treatment of traffic barriers. Evidence suggests that crossing location, traffic volumes and land use characteristics of the street or street section under investigation, are factors which should be addressed in studies of pedestrian mobility and activity patterns, and in assessments of the traffic barrier effect.

Accident rates are higher at Zebra crossings than at Pelican crossings (Road Research Laboratory, 1963; Rayner, 1975; Bruce and Skelton, 1977; Hunt and Griffiths, 1989) and the use of pedestrian refuges, which are primarily provided for convenience and not safety, can increase pedestrian casualties (Thompson, Heydon and Charnley, 1990; Lalani, 1977). Reductions in traffic speed, following the implementation of traffic calming and low speed areas such as the 30 km/h zones, and reductions in traffic levels following pedestrianisation, clearly reduce the numbers and severity of casualties (Danish Council for Road Safety Research, 1989; Faure, 1992; Herrstedt, 1984; Hodge, 1992). Yet no evidence is supplied as to whether this is a direct result of the increase in convenience and reductions in associated barrier effects, by way of detailed pedestrian movement and activity data, for these locations.

2.3 PREDICTING PEDESTRIAN FLOWS FROM DIFFERENT LAND USES AND THE DEVELOPMENT OF PREDICTIVE EQUATIONS

A significant body of literature exists which seeks to analyse pedestrian flows by developing models. These studies indicate factors which are likely to be important factors affecting pedestrian activity. Models of pedestrian flow and movement patterns have been developed for a number of purposes. These include: to highlight constraints of the existing pedestrian network; to assess the impact of decentralisation on existing town centre facilities; to assess the attraction of workers to shopping; to assess the impact of a new road on an area; the future levels of walking and their distribution; and to determine where pedestrians walk and the improvements required to the pedestrian environment. Models have also been developed for stations in the London Underground (Annesley, Dix, Beswick and Buchanan, 1989; Daly, McGrath and Annesley, 1991; Buckman and Leather, 1994) and for a bridge used by a large number of pilgrims to Mecca (Selim and Al-

Rubeh, 1991). These models estimate pedestrian routes and congestion in situations which are free from motorised vehicles and are also typically situations where there is concern that high pedestrian density could result in serious personal injury, due to over crowding. May, Turvey and Hopkinson (1985) have identified 2 principal groupings of models used to predict pedestrian numbers:

> "1) A trip rate approach which seeks to identify the number of pedestrian movements at a point in time and at a particular location.
>
> 2) Models which relate to transport planning and involve some element of trip generation, attraction, distribution and assignment." (May, Turvey and Hopkinson, 1985, P14)

This grouping is used in the following review.

2.3.1 Trip rate approach

In a study of Manhattan, Pushkarev and Zupan (1971;1975) attempted, using aerial photography, to relate the "density of pedestrians associated on average with a given building density" (thus avoiding the issue of trip distribution and trip assignment to specific paths) in an attempt to relate pedestrian flow to design standards (Pushkarev and Zupan, 1975, P26). The study derived multiple correlation equations in order to assess relationships between pedestrian density and independent variables (by floor space) such as walkways; office space; retail stores; restaurants; and the proximity of these to the nearest transportation terminus. The equations derived were only moderately successful with street equations explaining 61% (midday) and 52% (evening) of the variation in the presence of pedestrians and 36% (midday) and 23% (evening) in the case of avenues. The authors stated that this considerable variation was due to the platooning of pedestrian flow caused by traffic lights which affected avenues more than the longer street sections and secondly, because the intensity of use varies between buildings within a particular land use category. Lautso and Murole (1974) used a similar approach, using aerial photography in a survey of pedestrian volumes, in Helsinki. The data obtained was used in regression analysis to determine where pedestrians walk. The model was supplemented by an interview survey to assess the pedestrian environment.

Behnam (1977) developed a model which could be used for predicting pedestrian volumes from land use data in the central core of the central business district of Milwaukee. Each block was classified according to the land use at the mid-block location. A stepwise regression technique was used to discriminate and enter into the model the most significant variables that influenced pedestrian flow. These were: commercial space; office space; cultural and entertainment space. Ranking and Hill (1972) studied pedestrian traffic generation of major office and retail buildings in Australia Square, Sydney. This produced unit generation rates which were found to be dependent on time of day and type of floor space. Similarly, Hasell (1974) used a generation rate technique based on gross floor area, in a study of shopping in Central London.

Few local authority studies have been undertaken (May, Turvey and Hopkinson, 1987, P18). However, those local authorities which have undertaken studies such as Greater Manchester (1978) and Barnsley (1976) have relied on the work carried out in the Coventry Transportation Study (1973) for their study methods. The model, in its infancy, was outlined briefly by Edwards and Shipley (1972). The Coventry Transportation Study (City of Coventry Council, 1973) attempted to determine numbers of pedestrians exposed to traffic conditions in different locations. Due to costs involved in obtaining pedestrian count data, the study attempted to develop models for predicting numbers of pedestrians from readily available land use and transport data. The Coventry model suggested that it was impossible to attempt to predict pedestrian numbers in the Coventry central business district due to the difficulty in correlating numbers of pedestrians with land use variables, especially frontage shopping floor space. However, for district or suburban shopping centres the study revealed that the numbers of pedestrians present were highly predictable. The model used only produced relationships for the crossing flow and pavement concentration, but did so for differing age groups. The best predictive model for crossing flow and for numbers in the street (pavement concentration) related solely to retail floor space in the street.

More recently, the Coventry Model has been tested by researchers at the Institute for Transport Studies, Leeds University, in a Transport Research Laboratory (TRL) sponsored programme (May, Hopkinson and Turvey, 1987; 1991). Both models used in the Coventry study were tested using data collected for the TRL study and were found to be "extremely poor" predictors of pedestrian numbers. Alternative models were developed and dependent variables representing pavement flow, crossing flow and pavement concentration were tested against a number of explanatory variables: retail floor space, population, public transport provision and adjacent pedestrian, parking and shopping facilities. Problems with data arose over obtaining adequate retail floor space data, and in keeping definitions consistent and data up-to-date. Data at street level and employment data were found difficult to obtain, resulting in the abandonment of employment data as a possible explanatory variable. Variables, apart from bus flow and distance from a station, were included as dummy variables. Most best fit models included one or more dummy variables with high coefficients, resulting in inaccurate validation. As a result, simpler models using 3 parameters: population, retail floor space, and bus flow were tested. Pavement flow models produced high correlations but validation was poor. Similar results were obtained for crossing flows but validation results were slightly better. The study concluded:

> "...it is not yet possible to produce reliable predictive models for either of these variables. A wide range of sites and planning parameters will be required if such methods are to be produced" (May, Hopkinson and Turvey, 1987, P25).

Pavement concentration models on the other hand produced somewhat lower correlations, but much better validation results. Both the model with dummy variables and that without estimated pavement concentration to within 30% at 3 sites. The study concluded that further work was required on models for pavement and crossing flow.

2.3.2 Transport planning approach

One of the earliest attempts to measure circulation patterns and forecast future patterns was made by Morris (1962). In this study, data was collected using street interviews and questionnaires deposited at offices, manual counts were also made at offices and mid-block locations. Generation rates for offices were derived and an analysis of shopping data gave estimates of the number of intermediate stops made by pedestrians on different types of trip. A gravity model was employed to test the attraction of workers to shopping. Morris also investigated the mutual attraction between shops.

Hill, Akers and Baker (1964) in Edmonton, Canada also used a gravity model to predict the needs of pedestrians in 1980. On-street interviews provided data from which it was possible to determine walking distance distribution and the representative attraction and generation rates. Pedestrian flows were estimated by means of a tree building programme, a gravity model including an adjustment to satisfy generators and attractors and a minimum path assignment programme. Pedestrian circulation, through a tunnel network of Carleton University, Ottawa, was studied by Hass and Morall (1967). Data sources included an origin and destination survey of trips and screenline counts of all links of the system at peak conditions, to allow the simulation model to be calibrated. Walking time and distance measurements were obtained using a technique akin to the moving observer method. The model developed was based on correlation which the authors considered was reasonable for future projections.

Ness, Morrall and Hutchinson (1969) undertook a study in central Toronto based on an office questionnaire survey, in order to develop a pedestrian model. A gravity model was developed assuming a gross modal split and trips were distributed from offices to all transport termini in the area. Trip generation rates for each transport mode were derived from employment data and the existing modal split. Attraction rates for the transport termini were based on observed volumes. The attraction of a particular terminus was assumed to be proportional to the fraction of all users of that mode existing at that terminus and to total office employment. Trip length distribution curves from the final calibration of the model, showed good correlations with observed data.

Scott (1974) developed an entropy-maximising model of a pedestrian flow system. The model assumed that there was a basic network of streets carrying pedestrian traffic and that certain nodes were gateways in and out of the system. The theoretical model, based on a linear network, sought to define a maximally likely (entropic) numerical pattern of flow, and utilised a complex spatial attractiveness function which related directly to the indices of retail activity.

Percivall and Sandahl (1972a, 1972b), with decentralisation of retail functions in mind, used a similar approach to illustrate the effects of these proposed changes on the physical structure of the central area of Orebro in Sweden. The town centre, for the purposes of the model, was divided into a matrix system related to street length between blocks. Figures for effective net floor area, were related to that matrix which included the shops' main entrances. From the model, it was found that deviations from actual conditions were so small that the map of the calculated number of pedestrians had the same appearance as the map of the observed number of pedestrians.

At the Institute of Transport Studies, Leeds, a distribution model of pedestrian movements was calibrated and tested. The study spawned a number of reports (Copley and Maher, 1973a; 1973b; 1975; Copley, 1975a; 1975b). The model based on the entropy maximising principle of Scott, however, did not record a particularly good fit. More recently Koyama, Hanzawa and Fukuda (1992) proposed a technique for estimating pedestrian flow in a central business district. They outlined a technique to update a trip distribution matrix by using the entropy model developed by Wilson (1970). The technique was applied in the centre of Tokyo in the Ootemachi district.

Johnson (1972) in his paper outlined a pedestrian model based on a household survey. Data was collected in order to assess the severance effect of a new road in the area. Based on an unspecified area called "Pedville"- a residential area 3 miles from the centre of a major conurbation - the survey focused on walk trips with an origin and destination in the survey area for all respondents over 5 years old. Analysis was based on household categories for trip generation with an adjustment for accessibility. The distribution model used was calibrated using an exponential friction factor function.

Ballas (1976) reports on the results of origin and destination surveys, carried out by Montana State University. In this work, trip generation and gravity model approaches were used. The predictive accuracy of each model was then assessed.

Spillers and Sanders (1973) attempted to develop a model of pedestrian flows in Hammersmith, London, concentrating principally on access trips. The model was based on the assumption that all people walk at the same speed and that there is no capacity restraint on links. Minimum distance was used as the route choice criterion in the assessment. Similarly Borgers and Timmermans (1986), in a study based on the central pedestrian area of Maastricht, designed a model of route choice which assumed a desire to minimise distance. A simulation model was built and good correlations were found between their model and observed pedestrian behaviour. The model successfully predicted 52.4% of the observed routes.

Bland (1983) described the LUTE model of travel by bus, car and foot, which has been used to predict the levels of these modes in a set of hypothetical towns with a range of sizes, shapes and population densities. In LUTE, all origins and destinations are represented as spatially continuous distributions and Gaussian integration is used to estimate travel from one area to another. Mode and destination choice are assumed to depend on a weighted sum of travel times and monetary costs called the behavioural cost.

As part of the DRIVE programme, a model which simulates the flows of pedestrians over a length of street, which is significantly greater than the area around a single junction or crossing facility, has been developed recently (Timms and Cavalho, 1991; Timms, 1991). Timms (1992) has described this pedestrian model which aims at assessing the likely mobility and safety effects of putting in or altering pedestrian crossing facilities. Onto a defined network, pedestrians are 'loaded' in the form of an 'entry/exit' trip matrix, giving pedestrian flow per hour from each entry point to each exit point. The model seeks to simulate the trips of these pedestrians as they pass through the network by combining the supply and demand data. Such models can be important for planning and operating instantaneous demand responsive policies, such as traffic signal control measures, which depend on the detection of individual pedestrians and cars. Such measures can be expected to have their main effect in altering the time at which a pedestrian crosses a road, and secondly, may influence route choice i.e. whether a pedestrian changes the path, through a traffic junction and whether a pedestrian crosses on, or near to, a formal crossing facility. Yet such models also have problems associated with them, in that, if measures being planned are over a wider area other than a single junction or crossing facility, it may prove too cumbersome, in terms of the input data required and computing time.

This work though would seem to confirm criticisms made of the earlier models in the mid 1970's (Timms, 1992, P1; TEST, 1976, P14 and 17; Ness, 1972; Barrett, 1972). Firstly, pedestrian trips are far less homogeneous than vehicle trips in terms of journey purpose and route choice (Timms, 1992, P2; TEST, 1976, P14). This is illustrated by the assumptions made in the models, for example, Morris (1962) defined 4 categories of pedestrian trip: terminal trips to and from car parks, garages and bus stops; business trips, essentially trips other than a terminal trip which did not involve a purchase (either actual or potential); shopping trips oriented towards purchases; and miscellaneous trips. Trips involving a combination of differing categories of trips are ignored. In fact, Morris assumed that all other trips (miscellaneous) would comprise 10% of the total. Secondly, the pedestrian mode can often be a minor mode in a trip e.g. walking to a car park or bus stop. Thus the pedestrian part of the journey is completely dependent on other major modes, so that an independent pedestrian model is inadequate (Timms, 1992, P2; TEST, 1976, P14). This would appear to be the problem with the model proposed by Koyama, Hanzawa and Fukuda (1992) which proposes an estimating technique for pedestrian flow for the central area district of Ootemachi in Tokyo. It appears to ignore the fact that the area is served by a mass transit system which governs pedestrian flow to such a great extent.

At the macro level, a pedestrian network is much harder to define than a vehicular network since the assumption cannot be made that large links attract most of the traffic (Timms, 1992, P2; TEST, 1976, P14). Thus, sophisticated modelling techniques are questionable given the differing movement philosophy, i.e. the pedestrian movement philosophy of freedom of movement compared to the movement corridor approach, associated with vehicular traffic situations. Design criteria may be more applicable in assessing pedestrian movement requirements (Barrett, 1972, P2). Problems were encountered, for example by Edwards and Shipley (1972) when a coarse zoning system was used based on Enumeration Districts which omitted the detail of the short journeys and routes taken at the micro level. Finally, modelling can prove to be expensive. Ness (1972) argued that the benefits from changes in the pedestrian circulation system must therefore be large enough to justify the simulation of the changes (Ness, 1972, P6).

Others have also commented on the problematic nature of data collection, management and updating, especially for pedestrian and land use data at street level. When attempting to develop predictive models, researchers at Leeds found problems with maintaining consistent definitions for the data and found that data at the individual street level was often difficult to obtain (May, Hopkinson and Turvey, 1991, P67).

2.3.3 Conclusion

In considering the literature which has sought to model pedestrian flows and develop predictive equations two approaches have been identified: the trip rate and transport planning approaches. Both approaches have identified variables relating to land use, especially retail, and public transport provision as significant factors influencing pedestrian movement through street sections. This has implications for the provision of crossing facilities and the siting of other countermeasures, and the assessment of subsequent mobility, safety and barrier effects. Recent work (Timms, 1991; Timms and Cavalho, 1991) has sought to model the impacts on pedestrian route choice resulting from the alterations to or introduction of pedestrian crossing facilities. Problems with this study suggest that such models become cumbersome if measures are introduced over a wide area. Findings from other studies indicate that correlations between numbers of pedestrians and land use variables are poor in central area locations, as opposed to suburban shopping locations. Pedestrian movement and behaviour is affected by the level of retail activity present in any street situation and by other factors such as the location of crossing facilities, bus stops and traffic conditions. This implies that criteria relating to the assessment of traffic barrier effects should give due regard to land use type and other environmental considerations likely to effect pedestrian activity and mobility. Any assessments of traffic barrier effects are likely to be street type or street section specific.

2.4 THE LEVEL OF SERVICE AND SPACE STANDARDS

The significance for pedestrian behaviour of level of service and space standards has been thoroughly researched by several authors. Copley and Maher (1973) along with others have identified walking speed and the relationships between walking speed and the numbers of people walking (flow) as being of importance in relation to the functioning and design of walkways. Earlier work tended to suggest rigid design standards while the pioneering later work of Fruin (1970), Oeding (1963) and later Pushkarev and Zupan (1975) suggest more flexible levels of service.

2.4.1 Pedestrian speed and flow

The effect of age on walking speed has been investigated by the Road Research Laboratory (now Transport Research Laboratory) (Road Research Laboratory, 1965). More recently, Cunningham et al (1982), in an experiment on an indoor track noted that for pedestrians in the over 55 age group, walking speed was noticeably slower. This corroborates findings from a laboratory study of the walking patterns of men (Murray, 1966). Other studies have identified gender as an important variable. Empirical evidence suggests that women walk more slowly than men, with the result that the proportion of women in the sample will have a big influence on the walking speed of that sample (Boles and Hayward, 1978). This highlights the fact that stride, a function of body size is the most likely determinant of higher male walking speed. Evidence also suggests that women cope much better with crowding, while men become more aggressive and competitive; this would explain their greater walking speed (Freedman, 1975; Amato, 1981).

Oeding (1963) noted the effect of trip purpose on walking speed, thus identifying motivation as a key determinant. The study details the differing characteristics of pedestrian flow at manufacturing plants, general business traffic, sports events, and on shopping streets. The study found that workers leaving manufacturing plants attained high volumes of flow at high speeds, whereas shoppers attained 2/3 the flow at 3/4 of the speed. This indicated that different design considerations may be appropriate for different locations.

Gradients have also been identified as having an impact on walking speed. For gradients over 4%, speed gradually decreases as gradient increases (Road Research Laboratory, 1965; Bruce, 1965). Hoel (1965) identified temperature as a major determinant of walking speed with lower temperatures being associated with higher walking speeds. In addition, Hoel found that walking speeds were greater in the early morning; indicating the effect of motivation.

Bornstein and Bornstein (1976) and Bornstein (1979) have argued that the pace of life in cities, as measured by the speed of pedestrian flow, is a function of city size. Walmesley and Lewis (1989) identified problems with this work. These were that Bornstein and Bornstein's analysis ignored age and sex; which have a major bearing on walking speed (Cunningham, Rechnitzer, Pearce, and Donner, 1982; Murray, 1966; Boles and Hayward, 1978; Freedman, 1975; Amato, 1981). In addition, the impact of time of day and the role of density are not discussed in terms of their influence on walking speed. Walmesley and Lewis (1989) attempted to redress these weaknesses. Their study, though, found that walking speed does increase with the size of settlements, although the relationship was found to be less pronounced than was previously thought. In addition, the study found that walking speed is influenced by age, sex, levels of congestion, time of day and weather.

Other studies have illustrated the impact of flow or pedestrian concentration (density) on walking speed. Hankin and Wright (1958) investigated uni-directional speed-flow curves for pedestrians in subways. The studies found that the maximum flow rate was 27 persons per width per minute at a concentration of 0.13 persons per square foot. Although the studies did not consider the interaction between opposing flow streams, the results were used as the basis for subway design standards (Ministry of Transport, 1965; Department of Environment, 1966).

Navin and Wheeler (1969) had similar results to those of Hankin and Wright. From studies of Columbia University students, the maximum flow rate was 26.4 persons per foot width per minute at a concentration of 0.11 persons per square foot. From their studies, they recommended that a pedestrian lane should be 2.5 feet wide. Navin and

Wheeler also studied two-way flows on level footways and found speed-flow curves that were similar to those for uni-directional flow. At a concentration of 0.1 persons per square foot, they found that when the counter flow was very low at around 10%, the uni-directional capacity was reduced by about 15%, but when the flows were equally balanced, capacity was only reduced by about 4% due to the streaming effect of the flows; an effect which was found to become more pronounced as flows increased.

Foot (1973), following a pedestrian jam in central Birmingham's subways at Christmas in 1969, investigated pedestrian traffic characteristics and the effect of inclined ramps on walking speed and density. The study suggested that as most shoppers walk in pairs, subways should be 4 metres wide to allow 2 pairs to pass each other but that widths can be reduced when used only by commuters. More recently, research into the usage of pedestrian subways in Sheffield has indicated that nearside traffic flow level is a major determinant of subway use, with increasing subway usage associated with increased vehicle density (Dernellis and Ashworth, 1994).

Oeding (1963) in a study carried out in Germany, was concerned with all types of pedestrian facilities. Using both manual and photographic techniques, he examined pedestrian traffic on footways at 15 sites, chosen so that each of the trip purposes mentioned earlier, could be examined. For each trip purpose an envelope of walking speeds was obtained. Parkinson (1970) in an analysis of Oeding's work determined regression lines for each category on the assumption of a linear relationship between speed and concentration.

Older (1968) studied shopping streets; two sites in Oxford Street, London and one in Slough High Street were examined. Older assumed that the relation between walking speed and density was linear and derived equations from this work, although departures from linearity were noted at high densities over 0.3 pedestrians per square foot. Although Older noted the effect of streaming and the natural tendency for pedestrians to keep to the right, no measure of the extent of streaming was devised for the study. An attempt was made to measure proportions of pedestrians using the carriageway in relation to densities on the pavement. This proved to be extremely variable depending on other factors such as conditions governing the movement of vehicles and the extent to which people crossed the road beyond the limits of the street section. While Collis (1975), in reviewing the work of others, noted that pedestrians step into the carriageway when the density around them exceeds a value of 1 pedestrian per square metre.

In a study of pedestrian cross flow and performance, Khisty (1985) used time-lapse photography to examine the characteristics of pedestrians in corridors, passages and hallways. The data and analysis from the study were compared with the results derived from the theoretical gap analysis. The study suggests a design criterion which is to limit the maximum density in such cross flows to 0.8 pedestrians per square metre (0.74 pedestrians per square foot), corresponding to a space of 1.25 square metres per pedestrian (13.5 square foot per pedestrian) for the combined streams. These figures were found to match the result of the gap analysis and conflict study for a maximum of 80% of the conflicts (Khisty, 1985, P693).

2.4.2 Levels of service

The intermittent nature of pedestrian traffic, obstacles to pedestrian movement in the footway, and the platooning of pedestrian flow noted by Older, Oeding and later Pushkarev and Zupan resulted in an attempt to move away from rigid definitions of design concentration. Oeding (1963), and later Fruin (1970, 1971), devised scales for estimating the effects of changes in concentration, thereby defining a level of service for pedestrians (Highway Research Board, 1965). Despite this, it must be noted that recommendations for footways in Britain, are still defined in terms of the absolute capacity of the footway (Ministry of Transport, 1965; Ministry of Local Government and Planning, 1951; Department of Transport/Institute of Highways and Transportation, 1987) and in relation to new residential areas in accordance with Design Bulletin 32 (Noble, 1984).

In 1946, a Departmental Committee of the Ministry of Transport pointed out that in shopping streets there is a "dead width" of footway of up to 3 feet which is not available for pedestrian movement (Ministry of War Transport, 1946). A similar effect was noted on shopping streets (Older,1968). In a study carried out in Leeds, using time lapse photography, the effects of constrictions on the footpath, such as window shoppers and street furniture, were noted. The loss of footway width and it's effect on speed concentration and flow concentration relationships were also noted. These results were then used to establish a reasonable level of service based on Oeding's work (O'Flaherty and Parkinson, 1972, P438). Wright (1985), in more recent work, notes the effect of geometric delay due to obstacles/obstructions on pavements.

Pushkarev and Zupan (1975) suggest that Fruin's and Oeding's levels of service are too insensitive to pedestrian traffic conditions and that pedestrians experience stress at quite low levels of crowding. Pushkarev and Zupan (1975) went further and suggested revisions to their more sensitive service levels, to take into consideration the platooning effect of pedestrians at crossing facilities and the cyclical variation. These modifications indicate the much greater impact that platooning has on lighter volumes of pedestrians.

This would appear to be backed up by work carried out by TEST (1976) in Kentish Town and Putney Street, London, which suggests, that at quite low levels of crowding, pedestrians experience stress. In later studies, TEST have adopted Pushkarev and Zupans criteria for assessment purposes (TEST, 1985). Work by Gilbert and Ang (1986) also suggests that even at quite low levels of crowding pedestrians are dissatisfied with the standards of their environment. More recently, Tanaboriboon and Guyano (1989), following a video study of walkways in Bangkok, suggest that "pedestrian characteristics and movements may differ due to different cultural attitudes and physical structures" (Tanaboriboon and Guyano, 1989, P40). In line with this, they suggest levels of service which incorporate lower area occupancy/higher density characteristics of Thai pedestrians.

Morris and Zisman (1962) have pointed out that despite the choice of a level of service to suit a particular situation and to serve a certain level of volume, there is still the need for intuition when designing for pedestrians. Further work may be required in this area. Levels of service postulated by Oeding (1963) and Fruin (1970) have been criticised for being insensitive to pedestrian needs. Recent work suggests that pedestrians do experience stress at low levels of crowding (TEST, 1976; Gilbert and Ang, 1986). Results from other studies would appear to suggest that more consideration should be given to the effect of dead width especially on shopping streets (Older, 1968); geometric delay (Wright, 1985); and the requirements of pedestrians who have crossed the road crossing into streams.

Moreover, levels of service should be suggested that pay attention to the movement requirements of the elderly, shoppers carrying goods, and levels of accompaniment. Morall (1985) concludes that whilst level of service is important in the planning of pedestrian facilities; walking speed, flow and density may not be the best measure of quality of service. Morall suggests that perceptions are important and these will depend on noise, levels of congestion, safety, and ease of crossing. May, Turvey and Hopkinson (1987, P86) point out:

> "What appears to be lacking in our understanding of pedestrian level of service is clear empirical evidence of how people respond to the influence of other people in different situations and at different densities".

2.4.3 Conclusion

Studies of level of service and space standards have not been concerned with addressing the barrier effect. Pedestrian speed and flow characteristics and levels of service have been devised solely in relation to movement along footways. Nowhere have levels of service relating to the pedestrian road crossing experience been suggested. The findings of these studies, though, do have implications for any study which seeks to address the traffic barrier effect and it's impact on pedestrian behaviour. Oeding (1963) has indicated that pedestrian movement characteristics are situation specific. Trip purpose, in particular, has been identified as a major determinant of pedestrian behaviour. Studies also indicate that rigid definitions in design standards should be avoided when designing for pedestrians

(Morris and Zisman, 1962), and that perceptions of street environments are as important as measures of walking speed and flow (Morall, 1985). The implications for a study of barrier effects are: firstly, any standards which would seek to identify different levels of the barrier effect should give due attention to perceptions of pedestrian behaviour and of the street environment; secondly, that any traffic barrier subsequently identified is street situation/location type specific.

2.5 PEDESTRIAN CROSSING BEHAVIOUR

Studies of pedestrian behaviour, especially crossing behaviour, as well as relying on accident data, have relied on the use of a variety of observation techniques in both the natural road environment and under simulated conditions. Delay to pedestrians crossing, in relation to choosing an appropriate gap in the traffic to cross into, has been identified as one of the most important aspects of pedestrian and vehicle conflict and as a consequence, a lot of research effort has been devoted to this aspect of pedestrian behaviour (TEST, 1976). In particular, delay to pedestrians crossing at random points in the road network has been well researched and documented. Some studies have attempted to relate pedestrian delay to environmental capacity or standards, in an attempt to develop criteria, by which traffic volumes could be restrained and environmental quality preserved (Buchanan, 1963, P203-213; Crompton and Gilbert, 1970).

2.5.1 Pedestrian delay at random locations

Adams (1936-7) represents one of the earliest attempts to determine theoretically, the delay to pedestrians crossing the road. The assumptions made were that vehicle and pedestrian arrivals were distributed randomly (obeying the Poisson Distribution) and that a waiting pedestrian required a critical gap (seconds) in the traffic stream before crossing. Tanner (1951) developed this work further pointing out that pedestrians can cross roads in any of three ways and that delays differ accordingly: 1) wait until there is a gap in the combined traffic stream, and cross straight over; 2) wait until there is a gap in the far stream and then cross straight over; 3) wait until there is a gap in the near stream, cross to the centre of the road and then wait for a gap in the far stream. Equations were derived for mean delay for each crossing situation which showed how delays varied for different acceptance gaps. This work was subsequently extended by Mayne (1954).

Underwood (1957) assumes the maximum permissible delay to pedestrians should be that level at which the rate of increase in delay (with increasing traffic flow) begins to accelerate. From this minimum, vehicle flow figures are derived. In order to define the minimum pedestrian delay necessary he makes the assumption that on average, no more than one pedestrian should be waiting to cross at any one time. From these assumptions, expressions and graphs are derived indicating whether an uncontrolled crossing is required for various levels of pedestrian and vehicle flow. Other studies concentrating mainly on the assessments of pedestrian delay (Joint Committee of the International Association of Chiefs of Police and Institute of Traffic Engineers, 1946; Lawton, 1954) assume that the maximum delay between safe traffic gaps should not be more than one minute.

However, such theoretical simulations do have limitations. Firstly, pedestrian and vehicle behaviour differ from one crossing situation to another. Secondly, vehicle arrivals are often platooned rather than random; the arrival pattern often becomes less random as traffic flow increases, and as the traffic becomes more platooned delay to pedestrians decreases. So a major assumption is violated just as vehicle delays become substantial. Thirdly, pedestrians are more likely to act in groups or divert their routes rather than wait for an acceptable gap in the traffic. Finally, pedestrian gaps may not be constant. Each pedestrian may have an optimal gap (TEST, 1976, P27).

Ashworth (1971) argued that previous theoretical models consider that all pedestrians have the same gap acceptance or that there is a distribution of acceptance gaps and each pedestrian behaves independently in deciding whether to accept or reject a gap in the approaching traffic stream. Ashworth points out that while this may give a good representation of the situation under light traffic conditions with low pedestrian flows, in many cases, in practice, groups of pedestrians will be waiting to cross the traffic stream. Under these situations it is not meaningful to consider that pedestrians act independently, since the action of one pedestrian deciding to cross, in many cases, results in approaching vehicles giving way to the entire group of waiting pedestrians. The pedestrians concerned will then experience a shorter delay than that corresponding to their own critical acceptance gap. Ashworth uses a simulation model to represent this situation. With this model, average pedestrian delays for a given traffic volume are shown to decrease with increasing pedestrian volume.

Crompton and Gilbert (1970) found that an exponential relationship existed between delay and volume, pattern of arrival, and carriageway width which explained 83% of the total variation in pedestrian delay. Goldschmidt (1977) used a multiple linear regression technique to develop predictive equations of delays to pedestrians at random crossing points and managed locations in one and two-way London streets. At random and managed locations, in addition to traffic volume, delays were shown to be affected by traffic arrival pattern, the number of heavy vehicles, traffic speed and road width. Goldschmidt was primarily concerned with establishing environmental standards for a given traffic flow level, and the type of crossing facility necessary to minimise pedestrian delays. These relationships are used in the Manual for Environmental Appraisal (Department of Transport, 1983)(see figure 1.2). Buchanan (1963) noted that the relationships between pedestrian delay and traffic volume could be used as ways to define the environmental capacity for a particular area; the volume of traffic that an area could hold before physical restraint is required to maintain environmental standards.

Hunt and Williams (1982) argue that the phenomenon highlighted by Ashworth, where pedestrians form a group waiting at the kerbside, may occur on established pedestrian routes but that this type of situation is not likely to have a significant effect on delay for pedestrians crossing at random points. A simulation model was developed based on a number of assumptions. These were that:

1) pedestrians arrive independently at random, and cross independently of each other;

2) a pedestrian will use one of several methods to cross the road, these being that the:

    a) pedestrians may wait at the kerbside for a suitable gap in combined vehicle flow, then cross directly to the other side. Hunt and Williams note that this is open to a number of interpretations:

        i) the pedestrian may wait until there is a gap in the combined traffic stream;

        ii) the pedestrian may wait until there is a gap in the nearside traffic stream and a gap in the farside traffic stream; or

iii) the pedestrian may wait until there is a gap in the near stream followed immediately after by a gap in the far stream.

b) pedestrians may wait at the kerbside for a suitable gap in nearside flow, cross to the centre of the road and wait for a suitable gap in the farside flow before completing his/her crossing;

c) pedestrians may cross between stationary vehicles, for example, on the approaches to traffic signals or pedestrian crossings; and that

d) pedestrians may walk along the pavement while scanning vehicle flow and cross directly when a suitable gap appears. In this case, the pedestrian may cross in two stages, continuing to walk along the centre of the road while waiting for a suitable gap in vehicle flow to enable him to finish crossing.

Hunt and Williams compared their results with those of both Tanner (1951) and Goldschmidt (1977). They suggested that Tanner's interpretation of crossing method 1 is unrealistic and predicted excessive delays for this method of crossing the road. Hunt and Williams argue that this crossing method is open to a number of interpretations. However, agreement was found with crossing options 2a(i) and 2b. Hunt and Williams found that the range of delay derived by Goldschmidt is adequately represented by the range of methods of crossing the road they cite. However, the proportion of pedestrians delayed, predicted by each of the simulations for each of the methods, exceeded the level derived by Goldschmidt. Goldschmidt (1977) cast doubt on the validity of the measure "proportions of pedestrians delayed". At traffic levels above 1000 vehicles an hour, when the problem of delay was most severe, the proportion delayed became insensitive to changes in traffic level. Hunt and Williams also pointed out that the data collected by

Goldschmidt was related to traffic conditions in London where overtaking was unlikely to occur and where there were many interruptions to flow which cause bunching. Hunt and Williams suggested an alternative vehicle arrival pattern, based on bunching downstream of traffic signals. Hunt and Williams concluded that the prediction of pedestrian mean delay and the percentage of pedestrians delayed at a random crossing point was dependent primarily on the ability to adequately model the pedestrian crossing behaviour and vehicle arrival distribution, applicable to a particular site. The study also concluded that for pedestrians crossing at a random point:

1) pedestrian mean delay depends on the road crossing method used by pedestrians and on pedestrian gap acceptance threshold. This is likely to show substantial variation between different locations and may vary with time at a particular location;

2) the proportion of pedestrians delayed depends on the vehicle arrival distribution with fewer pedestrians delayed as the traffic becomes more bunched; and that

3) pedestrian mean delay at most vehicle flow levels on a single carriageway road which functions effectively as one lane in each direction, is likely to be below 15 seconds. Most pedestrians will experience some delay.

In a comparison of pedestrian mean delay at a random point with that at Zebra and Pelican crossings, under normal conditions, on a 2 lane road, Hunt and Williams also suggest that few pedestrians are likely to alter their journey route to use a formal crossing facility. Formal pedestrian crossing facilities were more likely to be used where they form part of an established route or where a high proportion of pedestrians were elderly or children.

In a recent study, Hunt and Griffiths (1991) describe road crossing behaviour along sections of road, described as "fairly busy", where crossing facilities are not available to give precedence to pedestrians. The study developed simple relationships in which pedestrian delay can be evaluated from variables such as pedestrian flow, traffic flow and speed, road width and layout, parking, land use alongside the carriageway, and distance to the nearest junction or crossing facility. Most pedestrians were not constrained to cross at a particular location but crossed as part of their journey, if a suitable crossing opportunity arose. These pedestrians suffered small or zero delays. Pedestrians were extremely adaptable in the strategy adopted, route taken and walking speed while crossing the road. Diagonal crossing, to save journey distance or time was found to be widespread, often undertaken in the presence of moving vehicles. Due to the adaptability and the substantial proportion of pedestrians who were found to be opportunists, the percentage of delayed pedestrians and pedestrian mean delay were generally low. Indeed, much of the overall pedestrian mean delay in the study was attributed to the few extremely cautious (usually elderly) pedestrians who suffered long delays. A high proportion of pedestrians had delays which were zero or very low. The study developed a simulation model in an attempt to take into account pedestrian adaptability, behavioural differences and pedestrians who were not constrained to cross at certain locations. Speed was found to have a negligible effect on pedestrian delay. The kerb to kerb road width does not affect pedestrian mean delay explicitly due to the effect of parked cars. Hunt and Griffiths argued that the effect of road width was minimal, and this was consistent with the observation that pedestrians concerned with crossing lanes of traffic will incur only minimal delay in taking up a position on the carriageway, often between or in the shelter of parked cars, before crossing the traffic stream.

2.5.2 Pedestrian delay at crossing facilities

Griffiths, Hunt and Marlow (1984a) developed computer simulation models of pedestrian crossing facilities, in a study of pedestrian delays at 74 Zebra and Pelican crossings. The study found that at both Zebra and Pelican crossings, pedestrians arrived in groups rather than singly and that the percentage of pedestrians operating the push button at Pelican crossings was dependant on vehicle flow. In addition, the percentage of pedestrians starting to cross during the 'Red Man' phase was found to be dependent on the vehicle flow rate. For the data observed, there was no significant difference in this aspect of pedestrian behaviour at Fixed-time and vehicle-actuated Pelican crossings. In further papers, Griffiths, Hunt and Marlow (1984b; 1984c; 1985) developed and validated models of delays (both vehicular and pedestrian) at pedestrian crossings. In their 1985 paper, mathematical formulae, for each of the pedestrian crossing types, were developed and a regression analysis of pedestrian mean delays against vehicle flow, using both their results and those of Goldschmidt (1977) was undertaken.

Hunt and Khalil (1988), in a study of pedestrian delay and behaviour at signal-controlled junctions using OSCADY, sought to demonstrate the consequences for cycle time when a pedestrian stage was included. Analysis of pedestrian behaviour at signal-controlled junctions revealed that most pedestrians crossed very close to the intersection. Those pedestrians who crossed away from the intersection usually walked diagonally across the road, rather than at right angles to the direction of traffic flow. This effectively reduced their journey time but increased their exposure to vehicular traffic. In the absence of a refuge, few pedestrians are prepared to wait in an exposed position in the centre of the carriageway, preferring to wait until vehicles are held by the red light.

Hunt, Griffiths and Hughes (1991) found, from a survey of local authorities operating SCOOT, that authorities were concerned about the increased pedestrian delay at Pelican crossings. An evaluation of alternative operating strategies for Pelicans, operating under SCOOT control, found that double cycling of Pelicans provided substantial benefits to pedestrians, with only small disbenefits to vehicles and their occupants. Double cycling ensures that the Pelican operates on a cycle time which is similar to that for Pelicans operating independently in uncoordinated areas. Where pedestrian flow is high and vehicle flow is low to moderate, the benefit to pedestrians of independent operation of the Pelican is greater than the disbenefit to vehicles and their occupants.

More recently, studies of the new Puffin pedestrian crossing have been undertaken. These new signals can retain the call to the 'green man' phase if a signal from at least one pressure sensitive mat is received. The studies have found that during periods associated with high pedestrian flow, an extension to the 'green man' phase did result, whereas periods associated with low pedestrian flow levels resulted in a decrease in the time allocated to pedestrians (Davies, 1992).

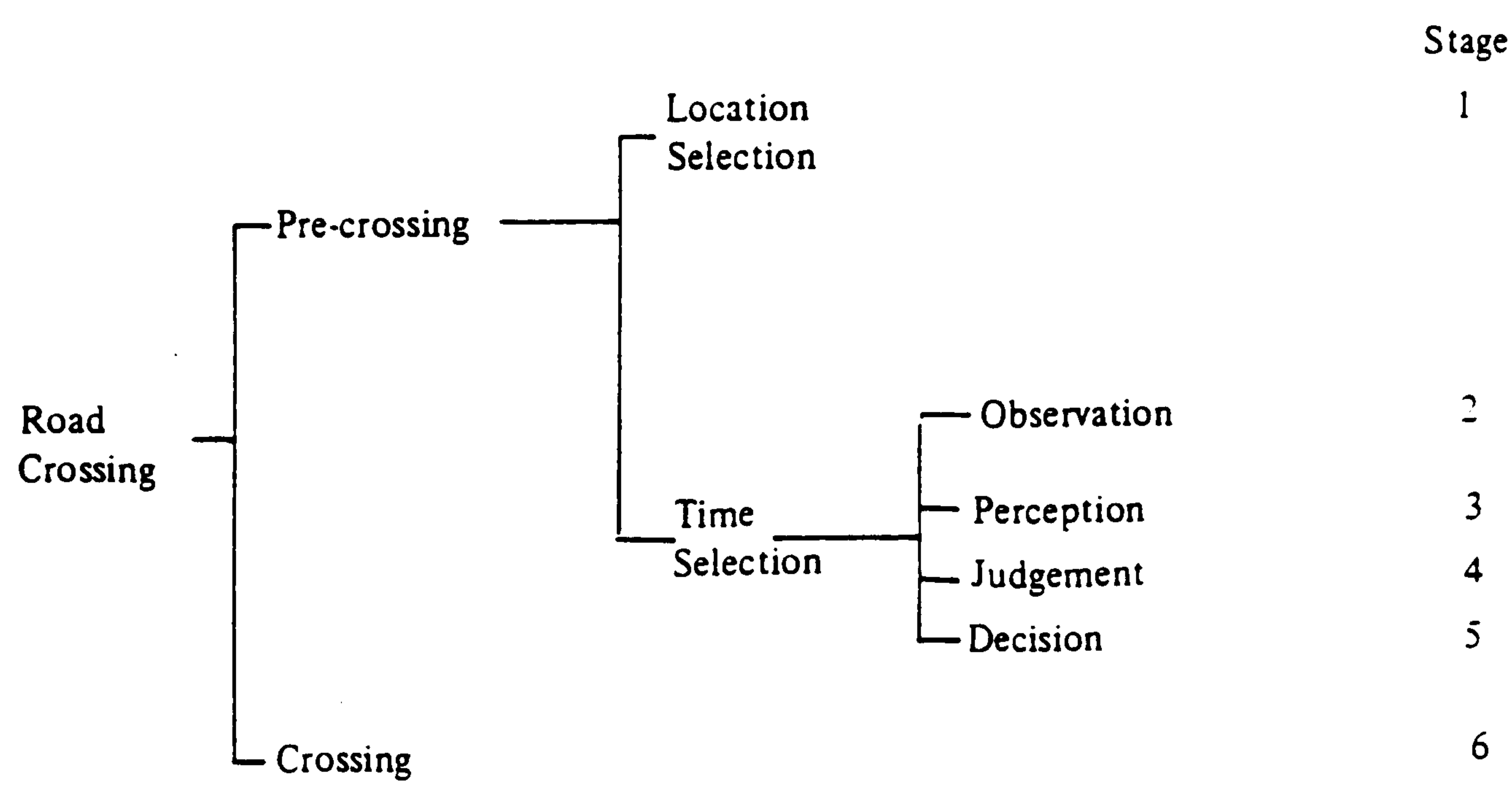
2.5.3 Pedestrian crossing behaviour studies

Direct empirical studies of pedestrian behaviour in traffic have primarily been used to identify the age differences in behaviour. Studies have made use of a variety of techniques in both the natural road environment and under simulated traffic conditions. Some studies have made use of observers to categorise pedestrian actions on a particular area of road (Sandels, 1975), while other observational studies have used tracking type methodologies (Routledge, Repetto-Wright and Howarth, 1974). More recently, the use of film-based techniques has gained impetus in the field of pedestrian research. Studies have used time lapse photography and video equipment, not only in the natural road environment, (Grayson, 1975; Wilson and Grayson, 1980) but also in simulated traffic situations (Firth, 1979; England, 1976). The emphasis in such studies is on normal behaviour and it is a point of contention whether such studies could or should relate to accident situations, which are comparatively rare events (Firth, 1982, P49). Studies have also been undertaken assessing the impact of the implementation of bus-pedestrian shared streets (TEST, 1990), and traffic calming schemes on pedestrian behaviour (Danish Ministry of Transport, 1987; Environmental and Transport Planning, 1990).

Heimstra, Nichols and Martin (1969) developed an experimental methodology for analysing child pedestrian behaviour. This was the first systematic description of child traffic behaviour in terms of directly observable variables, these being considered essential for building up a picture of behaviour. Grayson and Firth (1972) provided a more flexible structure, although concerned primarily with child pedestrian behaviour, minor modifications could be made to incorporate other age groups. A modified version of this task analysis appeared in Older and Grayson (1974) (figure 2.1). The stages represent an ideal sequence of events, the sequences may be merged or repeated before crossing takes place.

Older and Grayson (1974), in an analysis of time lapse film, found that elderly pedestrians made more head movements and a took a longer time before commencing to cross, compared to younger adults. While crossing, elderly pedestrians were found to make fewer head movements while crossing the road, than those in the younger adult groups. Child pedestrians were found to make more head movements before and during crossing than adults and waited longer before crossing. Adults were found to combine the observation and location selection phases of crossing the road, so that waiting time was minimised or eliminated. Children and the elderly seemed less able to do this. In addition, children exhibited a greater tendency to stop at the kerb. Older children were found to accept smaller gaps in traffic than younger children, implying that younger children spend longer on the kerb before crossing, when presented with an acceptable gap between vehicles. However, when in groups, both older and younger children appeared to accept shorter gaps.

Figure 2.1 The Pedestrian Crossing Task.



(Source: Older and Grayson, 1974)

Grayson (1975), using a film-based technique, confirmed these findings and added that adult pedestrians were more likely to cross at an angle, while running across the road was more common for child pedestrians. Grayson also noted that when adults accompanied children, children played less of a role in the crossing task. Wilson and Grayson (1980), in a study of age-related differences of crossing behaviour by adult pedestrians, found that the proportion of adult pedestrians with no kerb delay decreased significantly with age. Unlike kerb delay, delay in the road revealed no significant trend with pedestrian age. Total delay and as a consequence, total crossing time increased markedly with age. There was no trend associated with age in the impact of parked cars on pedestrian crossing behaviour. Age differences in behaviour were small and could not account sufficiently for the higher casualty rate of the elderly. Work undertaken by Wilson and Rennie (1980) also suggested that there were few differences in crossing behaviour between elderly and younger adults, although younger pedestrians accept shorter gaps in very heavy traffic. The overall approach, in terms of crossing strategy for the elderly, was similar to that of children.

An analysis of safety gaps (that is the amount of time each pedestrian had to spare over an approaching vehicle) undertaken by Wilson and Grayson (1980), revealed no significant differences by age, although there was a tendency for the proportion of pedestrians with small safety gaps (that is less than 2 seconds) on the farside of the road, to decrease with age. The proportion of pedestrians with small safety gaps was higher on the farside of the carriageway than on the nearside (5.2% compared to 2.5%). This was despite earlier work which indicated that the majority of pedestrians were injured on the nearside. This poor relationship between gap size and pedestrian casualty data led Wilson and Grayson to comment:

"safety gaps would not seem to be a reliable indication of a dangerous crossing manoeuvre, and may even be a reflection of skill in the crossing task" (Grayson and Wilson, 1980, P7).

In addition, the authors noted that gap acceptance measures were not a particularly fruitful area of research and that more detailed analysis of pedestrian/vehicle interaction was preferable. This assertion seems to have stemmed from evidence indicating a poor relationship between gap size and pedestrian casualties.

Despite this, the study of acceptance gaps (defined as the time of the gap between vehicles in which the pedestrian decides to cross) has been identified as an important area of research (Moore and Older, 1965; Dipietro-King, 1970). Opinions differ as to what is an acceptable gap. The Ministry of Transport (1965) recommended a gap of 5 to 7 seconds as acceptable. Cohen, Dearnaley and Hansel (1955), in a study of pedestrian behaviour in Manchester, found that 25% of pedestrians would accept gaps of 2 seconds or less, 50% were prepared to accept gaps 3.5 seconds or less, and 75% gaps of 5 seconds or less. The gap length required by pedestrians decreased slightly as vehicle speed increased. Jacobs, Older and Wilson (1968) showed that for vehicle speeds of 20 mph, the threshold gap for 50% of pedestrians observed was less than 3 seconds. One reason which has been cited for the difference between these 2 sets of observations is the methods used to collect the data. Cohen's observations include 1869 acceptance/rejection decisions for a sample of 491 persons. It is clear that multiple rejections were included in the observational data and this can be shown to give rise to a biased gap acceptance curve, in which there is no longer a direct correspondence between the percentage acceptance of a given gap size and the percentage of persons willing to accept a gap of that size.

Jacobs et al (1968) used a film based method, whereby each pedestrian appeared only once on the observation record (Ashworth, 1968).

Hunt and Abduljabbar (1993), in recognising the problems associated with pedestrian delay, have sought to develop an index of crossing difficulty based on gap acceptance and rejection criteria derived from a sequence of vehicle arrival times. Three index measures were defined:

1) the average crossing index based on the sets of gaps available at intervals (seconds) over an evaluation period (seconds) for all pedestrians.

2) the proportion of 30 second intervals which contain at least one period of 2 seconds when there is a crossing opportunity acceptable to 50% of pedestrians.

3) the proportion of 30 second intervals which contain at least one period of 2 seconds when there is a crossing opportunity acceptable to 85% of pedestrians.

Analysis using the index has indicated that the effect of vehicular bunching in the traffic stream creates more crossing opportunities particularly at high levels of flow. The work has also indicated that the provision of a pelican crossing reduces crossing difficulty for combined vehicle flow above 1000 vehicles per hour, while the ability of a Zebra crossing to provide acceptable crossing opportunities was found to decline as traffic flows increased. This reflected the increased difficulty pedestrians have in establishing their priority at Zebra crossings during periods of higher traffic flow. Measures 2 and 3 however, are based on average behaviour, the assumption that 2 seconds is an acceptable gap into which pedestrians can cross a 9.4 metre wide road. This approach, where indexes are derived from gap acceptance and rejection criteria for particular roads and locations, is cumbersome and requires re-calibration. It is also however, unsatisfactory for a number of other reasons. First, the approach is based on the supply of gaps in the traffic stream and not the pedestrian demand for gaps. An approach based on pedestrian demand would clearly indicate that 2 seconds is not an acceptable gap size for all but the fittest pedestrians. This study has suggested that this is especially the case when large numbers of children and the elderly wish to cross the road. Second, no reference is made to variations in mobility levels which reflect age, health and personal experience; the concern is with the "typical pedestrian". Clearly, all pedestrians need to cross the road. Third, the Crossing Index measure is concerned with those pedestrians who do cross, it is therefore a partial indicator of crossing difficulty experienced in any street environment. Factors such as deterrence and rescheduling are ignored.

More recently, a video study of child pedestrian behaviour, undertaken by the Scottish Office (1989b) found that only 35.3% of children stopped at the kerb, while 51.7% looked neither way at the kerb before crossing and 49.1% looked neither way when crossing the road. These results are clearly related to the high levels of adult accompaniment (46.3%) which can result in minimal child involvement in the crossing task. 22.7% of children were found to cross near parked cars; 73.4% walked across the road; and 71.1% were found to cross directly compared to 25.1% who crossed diagonally. Crompton (1979), in a video study of crossing behaviour, found that crossing angles and walking speeds were similar for all types of crossing location. The study also indicated that mean crossing angles were not affected by length of delay, but that mean walking speed was higher as a result of increased delay.

Salvatore (1974), in a study of judgements involving the speed of moving vehicles, suggested that age and sex are mediating factors in the accuracy of the judgement. Girls were found to display more caution than boys in that they tended to overestimate the speed of oncoming vehicles, and evaluate higher speeds more correctly. For all 3 categories of speed used in the study, boys gave better estimates. Older children were found to judge low and moderate speeds more accurately. Similarly, Lovell, Kellett and Moorhouse (1962) showed that age had a considerable effect on the perception of velocity, while Ziegler and Leibowitz (1957) showed that the ability to judge distance was also related to age. Avery (1974), in a review of literature on visual perception in relation to child pedestrian behaviour, suggested that factors such as speed of eye movement, attention and memory may be of importance in relation to differences between adults and children. Liss and Haith (1970) found that in choosing a location, children were slower than adults in processing the information. Finlayson (1972), in a study using filmed observations of children on school journeys, concluded that poor road behaviour was exhibited more often by boys than by girls.

Sandels (1975) suggests that there are differences between adults and children and that these differences can be grouped under 3 headings: physical, perceptual-cognitive and social-attitudinal. In a study of child pedestrian behaviour, the behaviour in traffic of 4-7 year olds was found to be unreliable and could be regarded as unsafe. In particular, 4 year olds displayed poor road behaviour more consistently than older children.

England (1976), in a study concerned with children's usage of crossing facilities, found that unless specifically instructed to use pedestrian crossings, few children did so.

However, children's usage of crossing facilities in the natural traffic environment have been found to be much higher (Firth, 1979). Firth (1973) and Fisk and Cliffe (1975), in studies of child pedestrian behaviour, suggested that road safety education can improve crossing behaviour.

Other studies of child behaviour have found that younger children selected the shortest and quickest route to a predetermined destination, and were unable to understand the importance of obstacles restricting their sight (Limbourg and Gunther, 1975). Almost all the children crossed at the green traffic light and fewer than half stopped before crossing and looked around carefully (Gorges, Bauerfeld and Schlagel, 1976). Howarth and Lightburn (1980) found that when boys and girls were involved in similarly difficult encounters with traffic, girls were more able to extricate themselves from those encounters.

TEST (1988; 1990), in a study of bus and pedestrian shared shopping streets in 8 British towns, found that pedestrian delay was closely related to the number of vehicles using the street. In Slough, where bus flows were 30 vehicles per hour, the mean delay to all pedestrians crossing the street was barely perceptible, ranging from 0.01 to 0.1 seconds. By comparison, in Sheffield, where bus flows were 320 vehicles per hour, mean delay for all pedestrians crossing was around 5 seconds. The study also provided evidence to the effect that as space sharing became more effective (i.e. where vehicle numbers are lower and travel slower) pedestrians were more evenly distributed across the street width and crossing angles were shallower. In contrast, in streets where vehicle numbers and speeds were higher, pedestrians were concentrated on the footways and their crossing angles were very steep, close to 90 degrees.

Similarly, studies of pedestrian crossing behaviour, following the implementation of traffic calming schemes, have noted the spreading out of pedestrian activity in these streets (Delft Public Works Department, 1973; Der Minister fur Wirtschaft, Mittelstand und Verkehr. des Landes Nordrhein-Westfalen, 1979). Studies of the Danish "3 Villages" Scheme in Vinderup suggested a substantial increase of 45% in pedestrian crossing activity following implementation of the scheme. Delays to pedestrians were found to have been reduced by 1 second (Danish Ministry of Transport, 1987, P34). On main streets, where carriageways have been narrowed or central islands provided, pedestrians crossed more easily and more frequently (SWOV, 1985).

More recently, research has found that the introduction of road humps has resulted in a reduction in waiting time at the kerb. This was linked with the reduction in vehicle speeds, which increased opportunities for pedestrians crossing (Jones and Farmer, 1993). Other work has suggested that pedestrians are attracted to road humps and traffic islands when crossing the road. In a report to Hertsmere Borough Council, on a traffic experiment in Shenley Road, Borehamwood, a total of 182 pedestrians were observed crossing. 97 (53%) used all of the road hump and a further 12 pedestrians (7%) used it partially, although a sizeable minority (40%) crossed away from the hump. A comparison with pedestrian crossing behaviour before the road was redesigned, showed that pedestrians crossed the stretch of road in a more even distribution. Data also showed that when pedestrians were waiting to cross or in the process of crossing, 17.7% of vehicles stopped to give them priority. These drivers, in effect, treating the road hump as a Zebra crossing (Environmental and Transport Planning, 1990).

2.5.4 Conclusion

Studies of pedestrian crossing behaviour have focused on delays to pedestrians whilst waiting to cross into an appropriate gap in the traffic stream, at a random location. This has been done chiefly through theoretical simulation (Adams, 1936-7; Tanner, 1951; Mayne, 1954; Underwood, 1957; Goldschmidt, 1977; Hunt and Williams, 1982; Hunt and Griffiths, 1991). Such studies however are limited in that they ignore the fact that pedestrian and vehicle behaviour differ from one crossing situation to another due to variations in the circumstances of individual pedestrians (TEST, 1976).

Models of pedestrian delay have also been devised in association with the usage of pedestrian crossing facilities (Griffiths, Hunt, Marlow, 1984a; 1984b; 1984c; 1985). Work has indicated that pedestrian delay is dependent on traffic volume, pattern of arrival and carriageway width (Crompton and Gilbert, 1970; Goldschmidt, 1977; Hunt and Williams, 1982; Hunt and Griffiths, 1991). Hunt and Williams (1982) have also indicated that in order to model pedestrian delay, an adequate understanding of pedestrian crossing behaviour is needed. They also suggest that few pedestrians are likely to alter their route to use a formal pedestrian crossing. Hunt and Griffiths (1991) have indicated that pedestrian delay is dependent on variables such as pedestrian flow, traffic flow and speed, road width and layout, parking levels, land use alongside the carriageway and distance from the nearest crossing facility or junction. They have also pointed out that due to the range of speeds recorded on urban streets, the effects of speed on pedestrian mean delay is negligible, and that due to parked vehicles, the effect of kerb to kerb road width on pedestrian mean delay is limited. Pedestrians would appear to be more concerned with crossing lanes of traffic, than the road as a whole. Traffic speed is of limited importance in determining the extent of barrier effects on central area urban streets. By comparison, traffic flow and vehicle arrival patterns would appear to be more important considerations when determining the extent of barrier effects on such streets.

Reliance on pedestrian delay as a proxy measure for the standard of the pedestrian environment is unsatisfactory. These studies have indicated that more information is required on pedestrian crossing behaviour. Such behaviour may vary in response to different traffic conditions, at particular locations over time, and between different locations. By implication, it is reasonable to assume that barrier effects will also vary at particular locations over time and between different locational/street types.

Other studies have focused on the age differences of pedestrian crossing behaviour (Grayson, 1975; Grayson and Wilson, 1980; Wilson and Rennie, 1980). Children and the elderly have been identified as taking more time over the road crossing task. By implication it would appear that children and the elderly, may be more affected by traffic barriers. Little has been done in these studies to address changes in pedestrian behaviour as a consequence of changes in traffic conditions, or the role of parked vehicles in relation to the pedestrian crossing task.

Studies based on theoretical simulations indicate that the vehicle arrival pattern, traffic volume, and the consequent gaps in the traffic stream are essential in any study of pedestrian crossing behaviour (Goldschmidt, 1977; Hunt and Williams, 1982; Hunt and Griffiths, 1991). An understanding of acceptance gaps is by implication also important to the study of barrier effects. Studies of pedestrian crossing behaviour following the implementation of traffic calming schemes also suggest that the interaction between vehicles and pedestrians is of major importance in assessing the impact of schemes. These studies also indicate that as traffic levels are reduced and speeds lowered, delays to pedestrians crossing are reduced and crossing angles become shallower (TEST, 1988; 1990; Danish Ministry of Transport, 1987).

2.6 PEDESTRIAN ATTITUDE STUDIES AND USE MADE OF THE STREET

A fourth group of studies exists. They differ from those previously discussed, in that they seek to refer to pedestrian attitudes and use made of the street. Traffic has been identified as having a detrimental effect on the pedestrian environment (TEST, 1976; Hopkinson, May and Turvey, 1987b). As a direct consequence of heavy traffic flows, work has also indicated that there can be a negative impact on pedestrian behaviour in terms of severance and barrier effects, and the number of trips made on foot (Appleyard and Lintell, 1969; Appleyard, 1981). Studies have also suggested that reductions in traffic levels and speeds have positive implications in terms of pedestrian use of the street. Some studies suggest that distance-related factors are also important in terms of route choice (Lovemark, 1969; Garbrecht, 1970;1971).

2.6.1 Attitude studies

Several studies have identified traffic levels as a major problem especially for pedestrians and residents. The National Environmental Survey (1972) found that 13% of respondents disliked traffic levels in their neighbourhood. Despite this however, the interaction between levels of environmental factors and general satisfaction with an area, in determining overall quality, is still unclear (May, Turvey and Hopkinson, 1987). Langdon (1976) has found that people's perceptions of environmental quality are related to their annoyance with noise levels.

Korte and Grant (1980) and Page (1977) explored the effect of noise levels on pedestrian behaviour but the findings from the studies are tentative. Mackie and Davies (1981) found that reactions to noise and fumes were more closely correlated with levels of traffic than to objective measures of these features. This would appear to suggest that satisfaction with traffic related environmental quality was closely related to traffic volumes. Similarly, mapping exercises have found that medium to heavily trafficked roads have a considerable effect on the extent and boundaries of perceived neighbourhoods (TEST, 1976; Lee, Tagg, Abbott, 1975; Lynch, 1960).

At a more detailed level, individuals do react to the effects of traffic and infrastructure on the walking environment. Lovemark (1972) found that willingness to walk varies with the quality of the environment. TEST (1976) in a survey of pedestrians on Kentish Town High Street and Putney High Street, recorded negative comments concerning traffic conditions, especially with regard to the volume, noise and proportion of heavy goods vehicles. Respondents for both streets also felt that crossing the road was difficult, footpaths were narrow and in poor condition.

Similar themes and responses were covered in a survey of pedestrianisation in Liverpool; namely that safety and freedom to cross were poor before the introduction of the scheme (Hills, 1976). Stewart (1981), in a study of pedestrianised streets, found that safety and ease of walking were the most important design elements (83% and 75% respectively).

Bennison (1980), in a study of the Tyne and Wear Metro, found that 56% of respondents had difficulty when crossing roads.

Hillman, Henderson and Whalley (1973), in a study of mobility in 5 areas, noted the preoccupation with traffic levels and their impact on pedestrian movement. The study revealed that the proportions of children allowed to cross the roads unaccompanied was higher in the village and outer suburbs where the perceived threat of motor traffic was less. This was reiterated in later work which revealed that levels of accompaniment are associated with traffic levels, dangers en route, and road crossing activity (Hillman, Henderson and Whalley, 1976; Hillman and Whalley, 1979; Hillman, Adams and Whitelegg, 1990). Further work revealed that respondents felt the number of pedestrian crossings were inadequate, traffic light phases were too short, and that they were disturbed by the speed of traffic (Hillman, Henderson and Whalley, 1976). Todd and Walker (1980), in a survey of adult pedestrian attitudes, found that parked vehicles, traffic speed, lack of pedestrian facilities, volume of traffic and junctions were the most frequently mentioned sources of danger. In addition, respondents stated that increased volumes of traffic, higher speeds, and larger vehicles on the road made crossing the road harder.

Hopkin, Robson and Town (1978) in a survey of the mobility of elderly people found that obstacles (kerbs, ramps, rails) are a major problem for pedestrians who have difficulty walking, 45% of elderly with walking difficulties found rails and ramps a problem. Road traffic and crossing the road appeared to be slightly less of a problem and is mentioned as a difficulty by 35% of registered disabled; 31% of elderly with walking difficulties; 16% of elderly with no walking difficulties.

In a survey, conducted by the Dutch Pedestrians Association (Voetgangers Vereniging, 1985), pedestrians reported problems on pavements and footpaths. The following problems were identified by respondents: rubbish, glass (71%); uneven pavements and footpaths (63%); cyclists on footpaths (59%); snow or ice (43%); cars parked on the footpath (43%); shop wares displayed on the footpath (38%); footpaths that were too narrow (38%).

Hopkinson, May and Turvey (1987b), in a study of the relationship between pedestrians' assessment of street environments and physical conditions, used a repertory grid approach in 15 centres. Respondents were interviewed against 13 constructs; 8 of which were related to traffic conditions. Most of the traffic-related constructs were not normally distributed. The rating for the amount of traffic was usually skewed to the bad pole. Investigation of the relationships between overall nuisance and total flow and goods vehicle flow showed tentative thresholds of 1000 vehicles an hour and 150 goods vehicles an hour. Hopkinson, May and Turvey (1987c), in a further study of households in 2 centres, Hazel Grove and Lanark, found that respondents in Hazel Grove were discouraged by traffic and environmental factors. By comparison, respondents in Lanark showed little concern over traffic-related issues.

Broome (1984) studied the extent to which heavy goods vehicles in the traffic stream contributed to residents' and pedestrians' rating of danger. The study found that noise was not a good indicator of nuisance but that fear was the most important pedestrian reaction to the presence of lorries. This, along with smoke and fumes was difficult to assess in terms of nuisance and their contribution to danger.

Crompton (1979), in a questionnaire and behavioural study of pedestrian delay, annoyance and risk on shopping streets in major and local centres, found that 54% of all respondents noticed being delayed. Of those noticing delay, 31% also felt some degree of impatience, 35% stated that they had difficulty in crossing the road, and a similar proportion were worried about their safety when crossing. At both formal and random crossing locations, substantial proportions of pedestrians noticed being delayed: 36% at Zebra crossings; 55.3% at refuges; 56.3% at traffic lights; 57.6% at random points; and 60.8% at Pelican crossings. At random crossing points and refuges substantial proportions found crossing difficult (45% at random points and 46% at refuges) and were also worried about their safety at these crossing locations (35.3% at random points and 41.3% at refuges). Further analysis revealed that for mean delays of up to 10 seconds, a 2 second increase would increase the proportion noticing their delay by a significant degree. For longer average delays however, a larger increase in mean delay of 5-6 seconds is needed to make a significant change in the proportion noticing. Correlations between difficulty in crossing and traffic volume, or carriageway width, or percentage of HGV's present were generally very low. Walking speeds or road crossing angles did not seem to reflect attitudes towards crossing difficulty.

Recent work suggests that the width of road to cross, amount of traffic, view of oncoming traffic, speed of traffic and the provision of crossing facilities make substantial contributions to the perceptions of risk for particular locations (Salter et al, 1993). The introduction of road humps and the closure of residential areas to through-traffic were viewed as being more effective than favourable, implying higher levels of personal cost in terms of reduced mobility and inconvenience to residents. By comparison, specific measures, such as more frequently marked pedestrian crossing points, were seen as being more favourable, implying little direct personal cost (Carthy et al, 1993).

Distance-related factors have been found by a number of studies to be important in terms of choice of route and as a consequence, pedestrian use of the street. Lovemark (1969) found that the most important criteria was length of route, while Severitne and Morall (1985), in a questionnaire survey of pedestrians in the central business district of Calgary, found that the quickest route was a predominant factor in decisions concerning choice of route. 50.7% stated they chose a route because it was perceived as the quickest, while 22% stated that they chose a route because they always used it. For those respondents on a shopping trip, attractiveness (in this case defined as the number of shops and facilities) was cited as the second most important factor influencing the choice of route after the quickness factor. Severitne and Fraser (1987) in a similar study, undertaken in Halifax, found that 56% of respondents selected a route because it was the shortest and quickest route, while 25% stated that the route they took was selected because it was a regular route for them. 5% selected the route due to the fact that they thought it was the only route available to them. Shop-to-shop trips and work-to-shop trips were found to be more influenced by the availability of opportunities and the attractiveness of the route.

Garling and Garling (1988), in a questionnaire study of pedestrians on shopping trips, attempted to ascertain whether on multi-leg journeys, pedestrians attempt to minimise distance between destinations or aim to minimise total distance. From a sample of 150 pedestrians aged over 18, 79 pedestrians had visited more than one location, 19% had minimised distance locally by choosing the first location closest to where they parked.

69% attempted to minimise distance by going first to the location furthest away and then minimising the distance back to the parking lot.

Garbrecht (1970; 1971) compared the frequency distribution of pedestrians along various routes and the likelihood of a route being taken as predicted by his behavioural model. Garbrecht assumed that pedestrians were distance minimisers. In a small survey of path selection by pedestrians in a rectangular parking lot, it was found that the choice of routes, after the initial direction had been chosen, was significantly influenced by the diagonal from origin to destination. Marchand (1974), in a study of pedestrian movements from and to a new subway station in a suburb of Paris, found a tendency for pedestrians to select the simplest route, even if it was not the shortest route, by walking to the main straight axis which was then followed to the destination. Recent work has suggested that the configuration of urban areas and design of pedestrian networks is an important factor to be considered in relation to pedestrian movement (Hillier et al, 1993; Kovacs and Galle, 1993).

2.6.2 Pedestrian use of the street

Gehl (1987) noted that pedestrians are likely to spend more time in the street if it is free from the intrusions of motor traffic and is orientated towards walking, sitting or standing. More recently, Gehl et al (1991) in a nationwide survey of streets and squares in Danish cities (of 5000-15000 inhabitants) noted that a variety of land uses in close proximity, combined with a high quality of design of public spaces and streets, created pedestrian environments which were well used and popular.

Appleyard and Lintell (1969) and later Appleyard (1981) refer to work undertaken in San Francisco and later in the U.K. and note that streets with heavy flows of traffic were perceived as being hostile, unfriendly places with sterile, uninteresting environments and little social interaction. Residents on streets with heavy flows mentioned excessive speeds as being dangerous, while residents on the lightly trafficked street found the street environment more friendly and less stressful.

Other studies of street use, following the implementation of traffic-calming schemes and pedestrian-orientated measures, have noted the rise in children's play and meetings in the street and other such informal, leisure activities resulting from changes in perceptions of the streets, following the implementation of improvements (Eubank-Ahrens, 1987; Guttinger, 1979). Following the implementation of traffic calming schemes, major beneficial changes in street activity can be achieved where more space is given to staying activities (Pharoah and Russell, 1989, P50). In the Berlin Moabit traffic calming scheme, street activities were reported to have increased by 60% and increases in non-motorised traffic (pedestrians and cyclists) were recorded on all streets where traffic calming measures were implemented, with the exception of Bremer Strasse (Dyckhoff, Guggenthaler, Silcher, no date). Surveys undertaken in the Danish "3 villages" programme indicate substantial increases in outdoor activities; in Vinderup the increase was as much as 47% (Danish Ministry of Transport, 1987; 1988). In studies of traffic calming in Nord-Rhein Westphalia, Germany, it was found that the pattern of street crossing activity was more diversified with pedestrians using more of the street (Der Minister fur Wirtschaft, Mittelstand und Verkehr, des Landes Nordrhein-Westfalen, 1979). Similarly, early studies of Woonerven in Delft also found that pedestrian activity spread across the street after conversion (Delft Public Works Department, 1973). Neeskens (1982) found however, that only a few inhabitants in a Woonerf were encouraged by the measures to spend more time out of doors. Similarly, surveys of residents as part of the Danish "3 Villages" schemes show that feelings of security for residents as pedestrians (and cyclists) increased following implementation of the scheme: in Vinderup, for example, 66% overall felt secure after implementation compared to 30% before (Danish Ministry of Transport, 1987, P34).

Other studies have looked at the impact of pedestrianised streets on pedestrian numbers. Data from numerous studies indicate that following pedestrianisation, there was a substantial increase in pedestrian numbers. Monheim (1980), in a study of the impact of pedestrianisation in Germany, argued that these changes are due to the possibility of using the street in a more interesting way; the increased accessibility to the city especially by public transport which made the cores relatively more attractive than sub centres, and out-of-town centres; and that the enhanced environmental quality of the pedestrian streets attracted people from other streets. Further analysis revealed that the largest pedestrian areas show the largest increases in pedestrian traffic. Similarly, other studies in the U.K and elsewhere indicated that following removal of traffic from streets, pedestrian flow generally increases (Roberts, 1981; TEST, 1981; Parker and Hoile, 1975; TEST, 1988; Norwich City Council, 1969; 1987; York City Council, 1988). Cashmore (1981, P47) however, notes that in Church Street, Liverpool following pedestrianisation, pedestrian flow declined by 15% over a 12 month period. Hills (1976) found that after pedestrianisation of a shopping street, also in Liverpool, the numbers of people attracted to the city centre had fallen slightly. Bus users in this study were also found to avoid one of the central bus stations because they disliked roundabouts and crossing the road.

However, the general trend following the removal or reduction of traffic in a street was one of corresponding increases in pedestrian flow.

2.6.3 Conclusion

Studies of pedestrian attitudes have not been concerned with traffic barrier effects. However, studies of attitudes do indicate that traffic levels are perceived as a major problem for pedestrians and residents (National Environment Survey, 1972; TEST, 1976). It is also clear that satisfaction with traffic-related environmental quality is closely related to traffic volumes. Features of streets such as noise and fumes were closely related to traffic levels, rather than to objective measures of noise and fumes (Mackie and Davies, 1981). Hillman et al (1973; 1976; 1979; 1990) have also noted the preoccupation with traffic levels in terms of the constraints that they place on pedestrian mobility. High levels of accompaniment of children were found to be clearly associated with perceptions of high traffic levels, dangers en route, and road crossing activity. Similarly, Todd and Walker (1980) found that traffic volumes, parked vehicles, traffic speed, and lack of pedestrian facilities were the most frequently mentioned sources of danger. Recent work would appear to confirm this (Salter et al, 1993). Pedestrian use of the street was also affected by traffic volumes. Streets with heavy volumes of traffic were seen as hostile environments, consequently little social interaction occurs (Appleyard and Lintell, 1969; 1980). Pedestrian route choice was shown to be also governed by distance minimisation, and the attractiveness of the route (Lovemark, 1972; Severitne and Morall, 1985; Severitne and Fraser, 1987; Hillier et al, 1993; Kovacs and Galle, 1993). Other studies have shown that where traffic levels have been reduced following the introduction of traffic calming schemes and pedestrian-orientated measures, there was notable increase in children's play and other informal activities and crossing activity becomes more evenly distributed across the street (Eubank-Ahrens, 1987; Guttinger, 1979; Pharoah and Russell, 1989; Danish Ministry of Transport, 1987; 1988; Delft Public Works Department, 1973).

These studies indicate that pedestrian perceptions of the street and resulting usage are affected by traffic flow levels. Traffic flow would appear to be of central concern in any study of traffic barriers and the implications of such effects for pedestrian behaviour. Also, features of the street such as noise and fumes are associated with traffic levels. The reductions in traffic flow, following the implementation of traffic calming schemes or pedestrian-orientated measures, and corresponding increases in informal street activity, as opposed to formal street activity such as the journey to work, would appear to suggest that the impact of traffic barrier effects on pedestrian behaviour is different according to trip purpose. Where non-essential journeys are involved, barrier effects may be maximised. Pedestrian route choice should be addressed in any study of the impact of traffic barriers on pedestrian behaviour.

2.7 IMPLICATIONS FOR THE STUDY: A SUMMARY

This literature review has identified a considerable volume of research undertaken on pedestrian issues. Little of this research effort has focused specifically on the relationships between pedestrian behaviour and traffic conditions and the extent of barrier effects experienced by pedestrians. However, the implications from previous work for any study of traffic barrier effects, are numerous.

Studies of pedestrian road casualty data, which have sought to address the impact of interventions in the traffic environment, have shown that age, walking situation, and the role of parked vehicles are important factors in relation to pedestrian safety and mobility which should be addressed in any study of barrier effects. However, such studies do not allow for or monitor changes to pedestrian flow and movement patterns following the introduction of pedestrian crossing facilities and countermeasures. As a result the trade-off between pedestrian safety and mobility, a trade-off central to the traffic barrier, has been largely ignored. In studying traffic barriers, attempts should be made to monitor changes in pedestrian flow and movement patterns in relation to the provision of pedestrian crossing facilities and accident counter measures. Where possible, this data should be disaggregated to highlight the impact of age and walking situation on behaviour. The problem with monitoring changes in the level of crossing activity however, is associated with the need to control for levels of activity to permit before-and after-comparisons.

Studies of casualty and accident rates at and in the vicinity of Zebra and Pelican crossings indicate that crossing location, traffic volumes and land use characteristics of the street or street section, should be addressed in any studies of the barrier effect. Findings suggest that traffic barrier effects, experienced by pedestrians, are not uniform within a street section and may be larger at locations near junctions and formal crossing facilities, and in street sections where retail land uses dominate. Studies have found higher accident rates and risks of becoming a pedestrian casualty higher at sites which exhibit these characteristics.

Research into the level of service concept and the identification of space standards, although not concerned with traffic barrier effects, are of some relevance. This work has indicated that pedestrian movement characteristics are situation-and trip-purpose specific. By implication, traffic barrier effects experienced may vary by trip purpose, i.e. they are lower for essential journeys and higher for informal street activities. Perceptions of the street have also been identified as being as important as objective measures of walking speed and flow. The implications are that perceptions of street environments should be considered as well as objective measures of pedestrian behaviour in any study of the barrier effect. Findings from the literature suggest that pedestrian attitudes and perceptions of traffic levels and traffic-related environmental quality, noise and pollution, are strong determinants of trip-making activity on foot. This would appear to be more so where choices and options are available, especially in relation to the non-essential journey or a journey which is not time specific.

Studies of pedestrian crossing behaviour have largely focused on pedestrian delay. However, the implications are that by focusing on pedestrian delay, or rather on those pedestrians who cross, the barrier effect is clearly underestimated. Attention should also focus on other behavioural measures and movement patterns in the street. The importance of traffic volume and the vehicle arrival pattern (or distribution of gaps in the traffic stream) have been highlighted. The effect of traffic speed and carriageway width on pedestrian delay has been identified as minimal, due to the range of speeds recorded on urban streets, where heavy traffic flows exist, and due to parked vehicles which offset the effect of carriageway width. Parking levels would appear to be an important consideration in the study of barrier effects, the implications being that kerbside parking makes crossing easier by narrowing the effective carriageway, and by enabling the pedestrian to choose a more appropriate gap in the oncoming traffic stream.

CHAPTER 3 METHODOLOGY

3.1 INTRODUCTION

The literature review has identified the need for methods to be developed and used which can directly assess the changes in pedestrian behaviour and movement, following changes in traffic conditions, or the implementation of traffic calming or management schemes. An understanding of pedestrian movement and behaviour, as well as perceptions of the street, are essential to a better understanding of the traffic barrier concept. A variety of methods need to be employed to assess the nature of the traffic barrier and it's effect on observed pedestrian behaviour.

Firth (1980) has argued that the apparent total reliance on accident statistics has unnecessarily limited the field of study to road safety, and that the study of pedestrian behaviour in isolation can never provide the answer to the accident problem. This view has been reiterated more recently:

> "It has perpetuated a fragmented and often intuitive approach to pedestrian behaviour. In order to overcome these problems it is necessary to put a new perspective on the research. First of all it is necessary to develop a meaningful and integrated research framework including all aspects of pedestrian research" (Firth, 1982, P65).

The methodology used in this study attempts to go some way towards redressing this methodological imbalance and opts for a variety of methods, as advocated by Firth (1980; 1982) and the OECD (1978; 1990). While this research is centred around pedestrian mobility and the traffic barrier it should be recognised that there is a trade-off between pedestrian mobility and pedestrian safety or perceived safety, an understanding of which is essential to the road safety problem. The study of the relationships between traffic and observed pedestrian behaviour, relationships which determine the extent of the traffic barrier experienced by the individual, clearly has implications for the design and implementation of traffic calming, bus priority "greenways", and other types of traffic management schemes. An improved understanding of these relationships would also greatly assist in setting clearer policies and priorities for the provision of pedestrian crossing facilities. These relationships are examined on selected sites in Edinburgh.

The central area of Edinburgh (figure 3.1), as in the case of other Scottish cities, has a high density of development consisting mainly of tenement flats; and is characterised by a substantial proportion of the city's population residing in areas adjacent to the central business core. Such a phenomenon can be found in many other European cities; but less often in England. The high density of development is reflected in high pedestrian activity levels and the importance of walking as a mode of transport in the central area, particularly along the radial routes. In addition, the central area of Edinburgh is characterised by high traffic and congestion levels, particularly on the many radial routes which feed into the centre. The trend towards generally higher speeds nationally with respect to aggregate travel is, therefore, not continuing on the busy radial central area roads in Edinburgh which are the focus of this thesis. Speeds have not been generally increasing on these streets - on the contrary, speeds have tended to fall as congestion spreads and capacity limits are approached over longer time periods. This has resulted in

Lothian Regional Council's stated intention to implement more bus priority measures and to police such streets more vigorously (Lothian Regional Council, 1993).

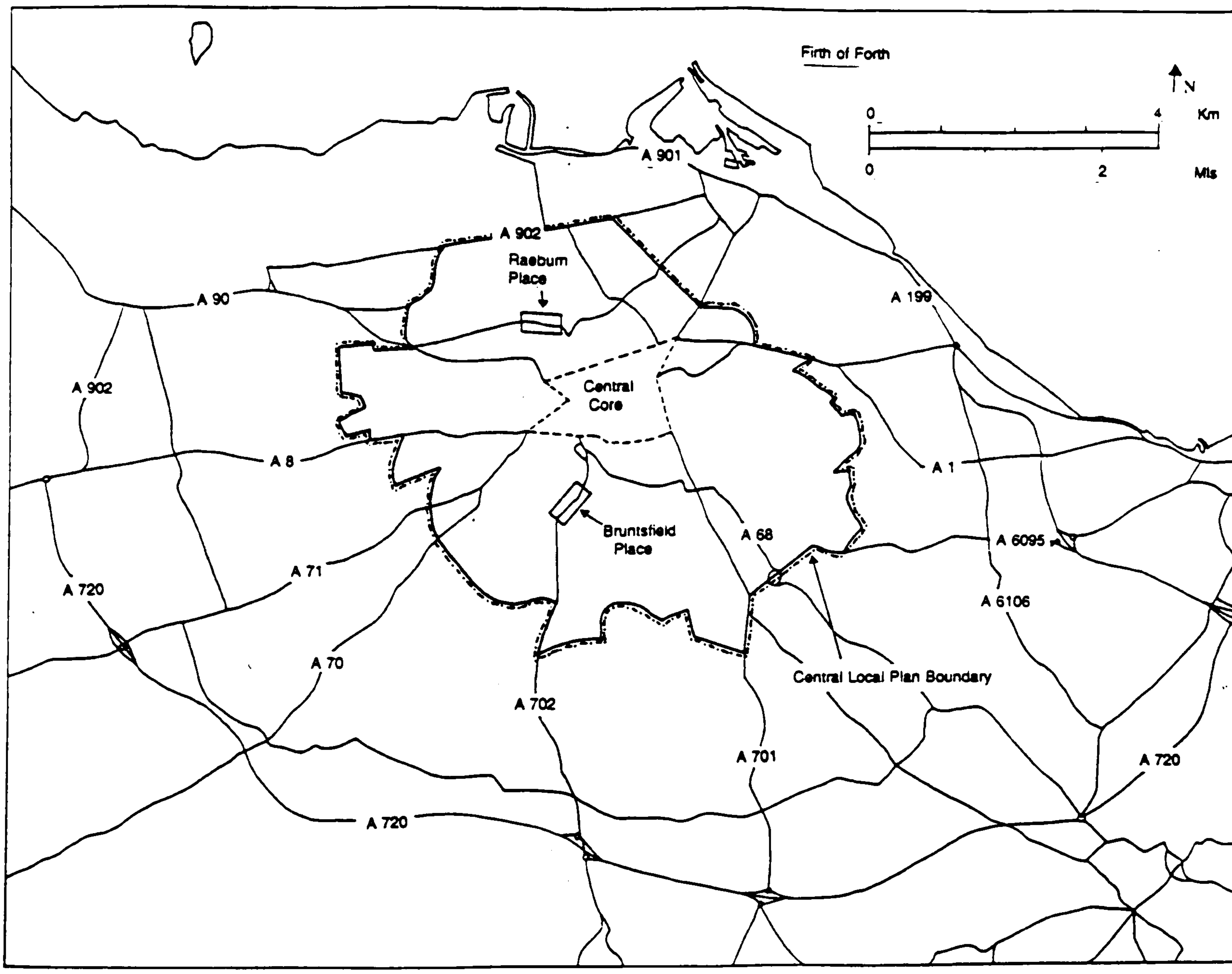
Despite the importance of these streets, no research has been undertaken of pedestrian behaviour on tenemental radial routes. Indeed, the land use and environmental circumstances of streets used in many behavioural studies is unclear. Models of pedestrian delay at crossing facilities and random locations have largely ignored locational and environmental factors (Crompton and Gilbert, 1970; Hunt and Williams, 1982; Griffiths, Hunt and Marlow, 1984a; 1984b; 1984c). Hunt and Griffiths (1991) studied pedestrian crossing behaviour on street sections, in England and Wales, which were described as "fairly busy", and identified the importance of environmental factors to pedestrian behaviour and movement. Wilson and Grayson (1980), in a study of adult pedestrian crossing behaviour in suburban shopping streets in Hounslow and Southampton, and Grayson (1975b), in a study of child crossing behaviour outside schools in Nottingham, ignored the importance of land use and environmental factors in their analyses. Work which has been undertaken on urban radial routes specifically, however, relates to the description and prediction of accidents and not directly to the study of observable pedestrian behaviour (Chapman, 1978; Silcock and Worsey, 1982; Lawson, 1986). The only work on Scottish radial routes, by McQuigan (1982), similarly focused on the description and prediction of accidents but did not identify which parts of the analysis referred to tenemental-radial routes.

The focus of this study is on streets in Edinburgh which have a residential/retail mix. This is a feature of radial routes in Scottish cities, with the ground floor of tenements fulfilling a retail use and the upper floors residential. The reasons for selecting these streets are that:

1) These radial routes have important functions for through-traffic and traffic related to local shopping, and serve as important public transport routes;

2) On these streets major pedestrian and vehicular conflicts arise, and there is a concentration of accidents.

Figure 3.1 Radial routes in Edinburgh.



3.2 PREMISES AND HYPOTHESES

This study is based on the following broad aims, these are to:

1) improve understanding of the relationships between pedestrian crossing behaviour, pedestrian perceptions of the street, and changing traffic conditions through the day;

2) improve understanding of the traffic barrier concept; and

3) highlight the implications of this study, in terms of the assessment of the impact of traffic on pedestrian behaviour and movement, for policy makers and practitioners.

The research is then based on two premises: firstly, that the use of speed management techniques, such as traffic calming, can result in a street environment which is more suited to pedestrian use, with a reduction in pedestrian trip suppression and severance; and secondly, that current practice promotes pedestrian deference to motor traffic in our street environments which in turn fosters severance and trip suppression.

The literature review has established that pedestrian crossing behaviour and perceptions of the street vary with the traffic speed and flow conditions experienced in the street. The main elements identified in the review of literature and in the study are that:

1) Age, walking situation and the role of parked vehicles are important factors in relation to pedestrian safety and mobility which should be addressed in a study of the traffic barrier (Hillman et al, 1976; 1979; 1990).

2) The lack of monitoring of changes to pedestrian flow and movement patterns following the introduction of pedestrian crossing facilities and countermeasures has raised doubts over claims of accident savings (Lalani, 1977; Thompson, Heydon and Charnley, 1990).

3) The focus on pedestrian delay, that is delay to those pedestrians who cross, has resulted in an underestimation of the extent of the traffic barrier. The indications are that long pedestrian delays are associated with high traffic levels (TEST, 1990), although there is evidence that platooning of traffic flow at higher levels of flow may decrease delays experienced by pedestrians (TEST, 1976);

4) Studies indicate that vehicle arrival pattern (the distribution of gaps in the traffic stream), traffic volume and gaps in the traffic stream are an essential consideration in studies of pedestrian crossing behaviour (Goldschmidt, 1977; Hunt and Williams, 1982; Hunt and Griffiths, 1991). Other studies suggest that as traffic levels are reduced and speeds lowered, delays to pedestrians are reduced, crossing angles become shallower and that the pattern of street crossing activity is more diversified with pedestrians using more of the street (Der Minister fur Wirtschaft, Mittelstand und Verkehr, des Landes Nordrhein-Westfalen, 1979; Delft Public Works Department, 1973; TEST, 1988; 1990; Danish Ministry of Transport, 1987).

5) The effect of traffic speed and carriageway width on pedestrian delay has been identified as minimal, due to the range of speeds recorded on urban streets where heavy traffic flows exist, and due to parked vehicles which limit the effect of carriageway width (Hunt and Griffiths, 1991). This suggests that traffic flow and not traffic speed is a major indicator of pedestrian crossing behaviour on central area urban streets.

6) Reductions in traffic levels and speed are also found to have beneficial impacts in terms of promoting pedestrian use. Pedestrians were found to spend more time in a street if it is free from the intrusions of motor traffic (Gehl, 1987). Appleyard et al (1969; 1981) note that streets with heavier traffic flows were perceived as hostile and unfriendly places. While residents on a street with lower traffic flow levels found the street environment

more friendly and less stressful. Other research has noted the rise in children's play, meetings in the street and other such informal street activities resulting from changes in perceptions of the street, following the implementation of street improvements (Eubank-Ahrens, 1987; Guttinger, 1979; Pharoah and Russell, 1989). The general trend following the removal or reduction of traffic in a street is one of corresponding increases in pedestrian activity (Roberts, 1981; TEST, 1981, TEST, 1988).

7) Formal crossing facilities have been identified as a feature of the street which are likely to attract a large number of elderly and young children, it has also been suggested that few pedestrians are likely to alter their route to use a formal pedestrian crossing (Hunt and Williams, 1982). Choice of crossing location and pedestrian movement characteristics may however be affected by route choice (Hillier et al, 1993; Kovacs and Galle, 1993) and by trip purpose (Oeding, 1963). Lack of crossing facilities and parked cars have been identified as a source of danger (Todd and Walker, 1980).

Each of these elements has been incorporated in the Edinburgh study and have influenced the study methodology adopted. This study seeks to address specifically, the nature and impact of the traffic barrier effect on pedestrian behaviour. In chapter 1 the traffic barrier was defined as:

> "the sum of inhibiting effects upon pedestrian behaviour resulting from the impact of traffic conditions within a specified environmental/street context. These effects can be either physical (observable) or psychological (unobservable) impediments to pedestrian movement."

It was also pointed out that:

> "Variations in the extent to which the traffic barrier effect is experienced will be influenced by individual pedestrian characteristics (age, walking situation, personal experience) and trip characteristics (journey importance, trip type)."

The traffic barrier effect refers to the operationalisation of the traffic barrier through observable changes in pedestrian behaviour resulting from perceived changes occurring in the street and traffic environment. In seeking to understand better the operation and function of the traffic barrier with a view to developing operational measures a number of hypotheses are tested in this study:

1) The extent of the traffic barrier effect on pedestrian behaviour is determined by actual traffic flow levels.

This is broken down into sub-hypotheses.

Observed pedestrian behaviour associated with heavy traffic flow levels is characterised by:

i) longer pedestrian delays;

ii) shorter acceptance gaps;

iii) steeper crossing angles;

iv) longer total crossing times;

v) the elderly and young children experiencing the extent of the traffic barrier effect to a greater degree (as measured by i-iv above).

2) Traffic speeds are not a significant indicator of the barrier effect on central area urban roads where traffic speeds and the variation in speeds are low, and where high volumes of traffic and parking activity occur.

This is characterised by low levels of association between traffic speed levels, in both carriageways, with:

i) pedestrian delay;

ii) acceptance gaps;

iii) crossing angles; and

iv) total crossing time.

3) The traffic barrier effect is mediated by kerb side parking in the nearside carriageway for those in the adult age group.

This is characterised by:

i) the perception that crossing into gaps in the oncoming traffic stream is easier;

ii) increased feelings of security and safety;

iii) shorter pedestrian delays;

iv) shorter acceptance gaps;

v) shorter total crossing times.

4) The perception of traffic flow levels by different age groups affects pedestrian behaviour.

Perceived traffic barriers, determined by heavy traffic conditions and low levels of pedestrian amenity, are characterised by:

i) perceived poor conditions for pedestrians associated with predominantly traffic-related features of the street;

ii) low levels of perceived safety;

iii) the usage of formal crossing facilities rather than crossing anywhere; and

iv) the wish to take a different route when walking, as mediated by the route's attractiveness.

3.3 STUDY METHODOLOGY

The study method involved the collection of data from several different sources. Pedestrian crossing behaviour was primarily studied through video analysis of variations in behaviour, related to traffic conditions, throughout the day. Video tape also provided data on traffic flow and speed and pedestrian flow. The video survey was supplemented by set format questionnaire surveys of local residents and pedestrians on-street which were undertaken to obtain data relating to perceptions of the pedestrian environment. Such perceptions are important in that it is perceptions of the objective conditions which are likely to influence behaviour. This survey approach was however, recognised to have several limitations. The respondents were constrained to the set format of the questionnaire; and the link between perceived traffic levels, behavioural response and perceptions of safety in relation to measurable objective traffic conditions, was left unexplored by this approach. Further work was therefore undertaken involving personal in-depth interviews across three age groups, using a specially edited video tape from which respondents perceptions and attitudes were sought in relation to a particular set of traffic conditions depicted on the video monitor.

In addition, accident data was obtained to indicate the extent and nature of the pedestrian safety problem on tenemental-radial routes in Edinburgh. This analysis of pedestrian casualties however, makes a doubtful contribution to an improved understanding of the link between changing traffic conditions and observed behavioural response for a number of reasons. These are that:

1) the extent of under-reporting or road accidents is high and varies widely (Bull and Roberts, 1973; Hobbs, Gratten and Hobbs, 1979; Tunbridge and Everest, 1988);

2) the number of pedestrian casualties is not a good measure of road safety. For example, a decline in the number of casualties can be explained by a road becoming more dangerous resulting in less pedestrian crossing activity and child pedestrians not being allowed to cross the road by their parents (Adams, 1985; Hillman, Adams and Whitelegg, 1990); and

3) the only way of exploring this issue would be to relate pedestrian perceptions of risk, in relation to traffic conditions at a particular time on particular stretches of road, to the actual number of casualties. In practice, these casualties tend to be too few and the police records too limited to allow for this. The details of this analysis are included in appendix 2. A summary diagram of the methodology used in this study can be found at the end of this chapter (table 3.1).

Appropriate streets were identified for the study, namely tenemental-radial routes characterised by a residential/retail mix. Both streets selected for the study - Bruntsfield Place and Raeburn Place - were found to exhibit those characteristics, described earlier, essential to the study. The streets are located in the late 19th century suburbs to the south and north of Edinburgh's city centre (figure 3.1). The Bruntsfield Place study was undertaken first. This study had originally been designed as a pilot study based on the availability and suitability of video records obtained from Lothian Regional Council. These had previously been used in a study of servicing arrangements on Bruntsfield Place. Although this study was more limited and used to test the methodology the data obtained was found to be more comprehensive and of a higher quality than had originally been anticipated. It was then decided that the Bruntsfield Place study would become the first stage of the study as opposed to a more limited pilot study. Some changes were made to both video and questionnaire studies following this first stage, and incorporated in a later second stage study which was undertaken on Raeburn Place.

The key element of this methodology was the use of the video in both the first and second stages of the study. Given a suitable vantage point the video provided simultaneous measures of a much larger number of variables than could otherwise be recorded. The measures included traffic counts, speed measures, pedestrian characteristics (age, sex, walking situation), pedestrian counts and measures of pedestrian behaviour. The supplementary questionnaire surveys collected data relating to perceptions of and attitudes to traffic conditions, and their impact on behaviour. The first stage study of Bruntsfield Place included two set format questionnaire surveys, one of residents and the other of pedestrians on-street. In the second stage, a survey of residents' attitudes and perceptions only, was undertaken. In-depth personal interviews were undertaken to complement the set format questionnaire surveys. These were designed to explore issues which the questionnaire survey had not fully dealt with, including the lack of data on the link between perceived traffic levels and of risk and behavioural response, and to obtain different qualitative data which would increase the ability to interpret questions of perception.

The sections of street selected for the video studies were 97 metres, on Bruntsfield Place, and 160 metres, on Raeburn Place. Both street sections were selected as they had a minimum of intersecting roads and formal crossings. This was so that pedestrian crossings outwith formal crossing facilities could be analysed on sections of street where vehicle turning movements were minimised. The street sections in both cases consist of tenemental buildings of a mixed residential/retail nature (plate 3.1 and 3.2). Bruntsfield Place and Raeburn Place are well served by public transport; bus stops are located in both sections of street chosen for the video studies. Restricted parking and waiting is permitted along the whole length of both street sections analysed (figure 3.2 and 3.3).

Bruntsfield Place

Bruntsfield Place, the first case study street, is of a high density, mixed use tenemental nature and acts as a major traffic route to the south to the Border Towns of Biggar and Peebles, and to the north of Edinburgh (see figure 3.1). It is also an important bus route as well as having a mixture of through and local traffic. The tenements on Bruntsfield Place and in the immediate surrounding area, where some villa-type developments can be found, were constructed in the mid 1890's (see plate 3.1 and figure 3.2). Unfortunately, there was, at the time of this study, no readily available data which could give an accurate indication of the size and composition of the local population. The flats in the tenements along Bruntsfield Place are popular with students and younger households. Households consisting of young families and also elderly person households tend to be located in the surrounding areas, adjacent to Bruntsfield Place. The shops on the ground floor of the tenemental developments along Bruntsfield Place are mainly of two types. Firstly, those which are orientated towards the needs of the local community such as chemists, butchers, newsagents, a public house, and bakery. Secondly, there are shops which are of a specialist nature such as delicatessens, designer clothes shops and jewellers, in addition to a building society and several estate agents. There are 2 schools located to the east of Bruntsfield Place, one primary and one secondary, which serve the locality.

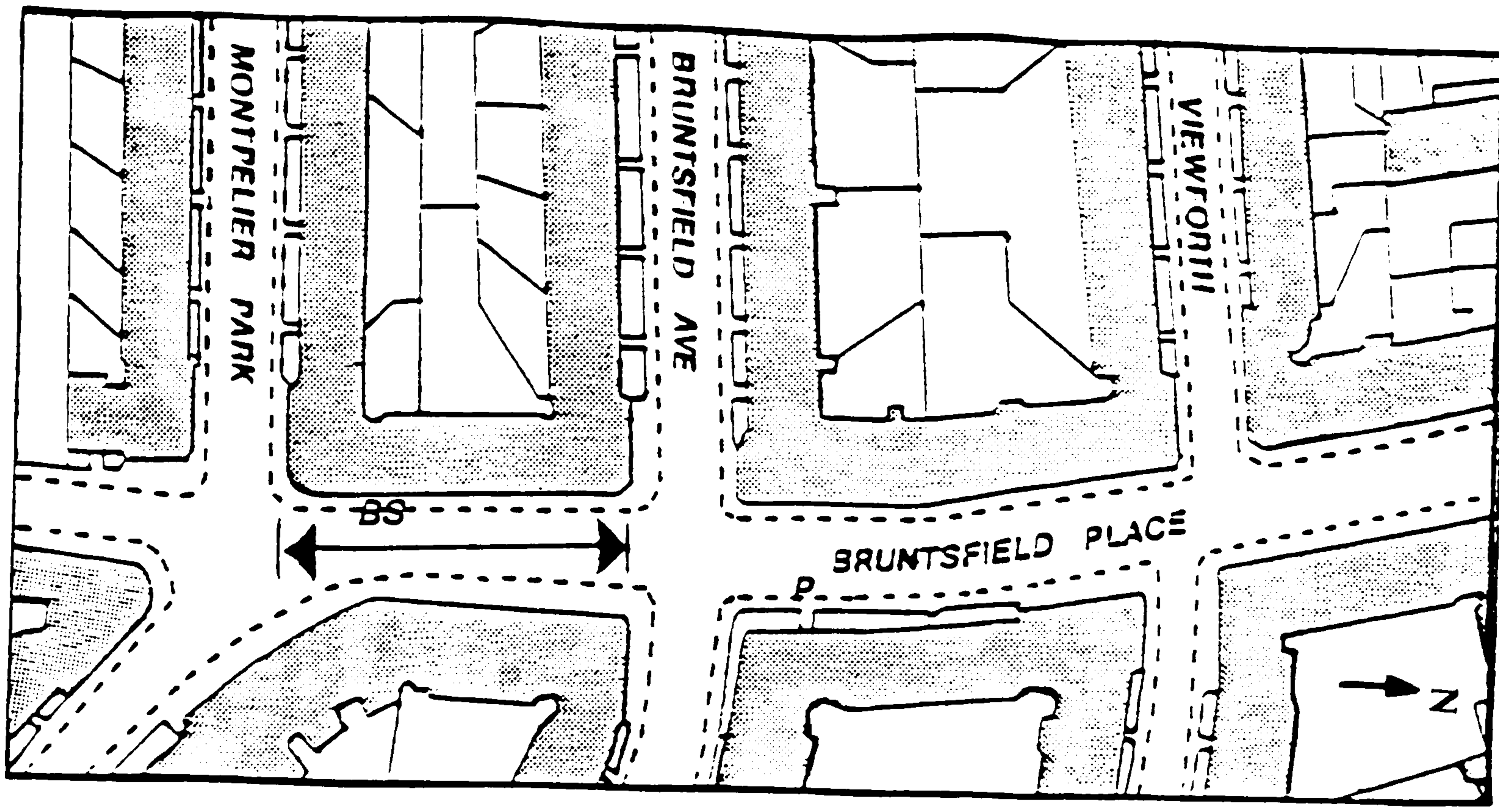
Raeburn Place

Raeburn Place, situated to the north west of the city centre, can also be described as a high density, mixed use tenemental street, but to a lesser extent (figure 3.1). The eastern end of the street section also comprises villa/town house developments which were also constructed in the mid-late 1890's. Raeburn Place is an important traffic route for both local and through traffic, serving as a main route into the centre of Edinburgh and for routes to the north west of the city centre (see plate 3.2 and figure 3.3). The street is also recognised as a constituent part of the Stockbridge district shopping centre, and as such, retail activity on Raeburn Place is slightly less intensive by comparison to Bruntsfield Place, where retail activity is concentrated on one street. Retail activity on Raeburn Place is characterised by small independent retailers such as butchers, fishmongers, newsagents and wine merchants. Unlike Bruntsfield Place, there are no specialist/designer type shops on Raeburn Place. These tend to be found elsewhere in the Stockbridge area. Households along Raeburn Place consist predominantly of students, young professionals and some families. As with Bruntsfield Place, households which consist mainly of the elderly and young families appear to reside in adjacent side streets. The immediate area adjacent to the north of Raeburn Place consists of sheltered accommodation and a day centre run by the Edinburgh and Leith Old People's Welfare Council.

Plate 3.1 Bruntsfield Place.

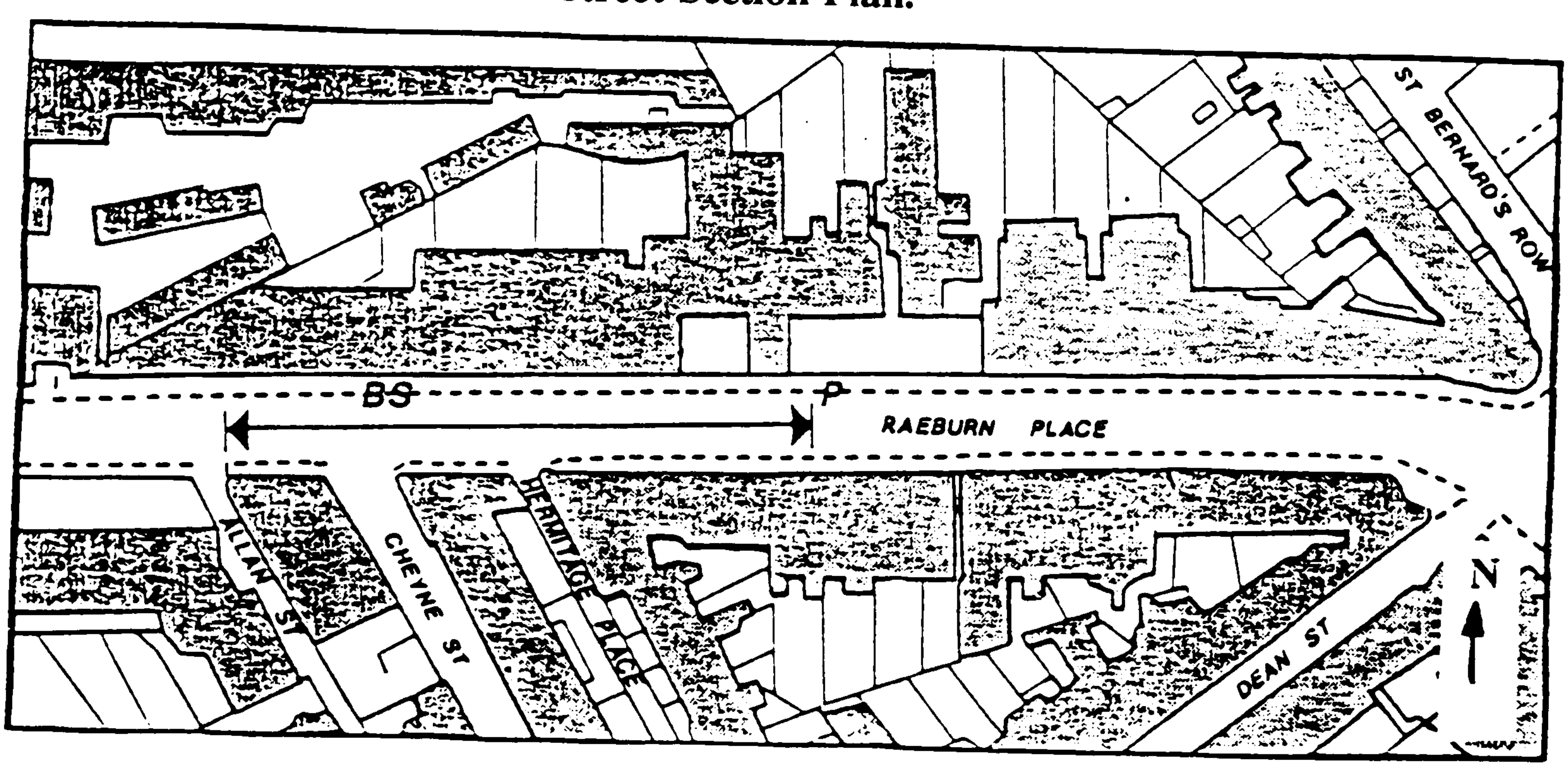
Plate 3.2 Raeburn Place.

Figure 3.2 Bruntsfield Place - Street Section Plan.



(Scale 1:25000)

Figure 3.3 Raeburn Place - Street Section Plan.



(Scale 1:25000)

KEY

⟷	Street section covered by video studies.
BS	Bus stop
P	Pelican Crossing

Bruntsfield Place street section length = 97.5 metres.
Raeburn Place street section length = 160 metres.

The methodology chosen, based primarily on a video analysis of pedestrian behaviour. permitting analysis of behavioural responses to variations in traffic conditions throughout the day, provided the necessary controls over the physical street environment in terms of road layout, adjacent land uses and other factors which influence pedestrian behaviour. This control enables traffic conditions to be assessed in relation to their impact on pedestrian crossing behaviour, with other aspects which may have an effect on behaviour held constant. This level of control would not be possible in a before-and after-study due to changes arising from scheme implementation or over the time period involved. Similarly, comparisons with other streets would not provide the necessary controls.

3.3.1 Video data

Little use has been made of video in previous research. A key element in this study has been to develop and evaluate the use of video for behavioural studies. The advantages of video over traditional manual methods, include:

1) a permanent and continuous record of events at low running costs;

2) it can be used, given a suitable vantage point, to provide simultaneous measures of a much larger number of variables than could be recorded otherwise including traffic counts, speed measures, pedestrian counts and pedestrian behaviour;

3) it can contribute to a reduction in the need for sampling which would have been required for the manual methodology; and

4) higher levels of accuracy can be obtained, video tape enables the data to be replayed and reviewed if required.

Data extraction from the video is time-consuming but there are clear advantages in terms of data collection (Turvey, May and Hopkinson, 1987, P4). Previous studies which have looked at pedestrian behaviour in some detail have used either time-lapse photography or video in a more limited fashion than that undertaken in this study (Older and Grayson, 1974; Grayson, 1975b; Wilson and Grayson, 1980). This study, through use of the technology of video, has sought through micro studies to investigate the impact of traffic on pedestrian crossing behaviour, and it has been able to do this more thoroughly than in previous studies.

The initial study on Bruntsfield Place made use of video tapes which had been used for a study by Lothian Regional Council in 1989. This study, by Lothian Regional Council had looked at the servicing arrangements for the shops there. As such, these tapes were found to have a number of limitations in terms of the length of street covered and the 12 hours of coverage (0800 to 2000) over one day. In addition to this, the video recordings, taken on Monday 23/3/89, were later found to correspond with a school holiday (17-3-89/3-4-89). Traffic conditions in the initial study did not show sufficient variations over the time period for which video data were available and hence, did not produce the extent of the variations hoped for in the pedestrian behaviour measures. As a result, the video records for the second study of Raeburn Place were extended to time periods in the evening on the weekdays used and were also extended to incorporate a Saturday. The second stage of the study used video tapes which were recorded specially. Two cameras, in weatherproof housings, were mounted on street light columns at first floor level (3-4 metres), one at either end of the 100 metre street section. In addition, remote VHS recording units were placed at the base of each column in security casings padlocked to the street light column. This enabled a 100 metre section of street to be covered over 3 days in October 1991 from 0800-2200 (Tuesday (22nd), Thursday (24th) and Saturday

(26th)). These dates corresponded with school holidays, but were the most appropriate, due to constraints such as the availability of the video equipment for hire. The extension of the video records into the late evening also proved problematic in that the onset of darkness made analysis of pedestrian behaviour and movement impossible after 1800.

Traffic flow and speed data

Traffic flow data was obtained from the video in consecutive 15 minute counts, from 0800 to 2000, for both directions for the Bruntsfield Place study and from 0800-2200 in the Raeburn Place study, for each day. One count was a vehicle passing a fixed point on either side of the carriageway. Traffic flows were recorded according to vehicle category type on count forms, as recommended by the Department of Transport (DTp/IHT, 1987, P62) (see appendix 1 for a copy of the count form used).

Traffic speeds were also recorded, in consecutive 15 minute periods for selected analysis periods, for both directions. These analysis periods had previously been selected on the basis of the variation in the flow conditions at the following times (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000. For the second stage of the study, an additional later time period was added from 2030-2200. From the video, space speed or journey speed was obtained (Taylor and Young, 1988, P148). This is the effective speed of a vehicle between two points.

For the purposes of both first and second stages of the study, the street section in both cases was marked and plotted on an Ordnance Survey map to obtain the distance between the two points. A systematic random sample of traffic speeds during each analysis period was taken from the video, based on a method advocated by Almond (1963). This had the advantage of providing a definite rule for sampling on the spot and of overcoming the problem that speeds will be biased in favour of the slower vehicles when overtaking is restricted (Almond, 1963; Brilon, 1977; McLean, 1978). Measurements of actual speeds of motor traffic can be taken for all of the vehicles on a road, as long as the flows are sufficiently low for all successive vehicles to be recorded. However, if the flow rate is too high or there is too much bunching this is not possible. Almond's method of measuring the second vehicle to arrive after completing the previous data observation is useful and should minimise the possible data error in sampling. This method is simpler and overcomes the problem of measuring the speeds of isolated vehicles or bunch leaders which will yield results biased in favour of the slower vehicles. The advantage of this procedure is that it is independent of the free speed distribution.

Pedestrian counts

Counts from the video were obtained as pedestrians were observed crossing a screenline marked on the screen of the VDU and were recorded on count sheets (see appendix 1 for count forms). The screen line is a line perpendicular to the carriageway. For crossing flows, counts were taken in the street section covered by the video camera. In addition, the counts were broken down into 15 minute periods corresponding to those periods used for the other data collected. The flows on each of the pavements were also broken down into directional flows, north and south. Although little information is available regarding the appropriate levels of disaggregation, each of the pedestrian flows was disaggregated in the following manner: a) under 18; b) 18-65; and c) over 65. These categories were chosen to represent children, adults and the elderly, and the age groupings should only be taken as indicators of these categories. Age categorisation of pedestrians is a judgement based on appearance. All video analysis was undertaken by a single observer, reducing the risk of observer bias and maintaining a level of consistency in data collection.

The pedestrian count data obtained from the video studies was used as the basis for the derivation of the crossing ratio measure. This ratio (expressed as a percentage of those crossing divided by total pedestrian flows) controls overall levels of activity existing at this time and enables comparisons of crossing activity level for different sections of the street by different age group to be made.

Observations of pedestrian crossing behaviour

A number of measures were selected from previous research into pedestrian behaviour. These were marked onto a grid for each observation from the nearside kerb to the farside kerb (see appendix 1). For the purposes of the initial study, crossing behaviour was only analysed from one side of Bruntsfield Place, the western side, for 12 hours, from 0800 to 2000. For the second study, crossing behaviour was initially analysed for both sides of the street for only two time periods on the Thursday: 1000-1300 and 1500-1600. This helped to reduce the time spent collecting data, as these periods were selected on the basis of corresponding with high levels of pedestrian activity. However, it later emerged that the time periods would need to be extended and video tapes for Tuesday and Saturday analysed, in order to obtain an adequate number of observations in each age group. For the Bruntsfield Place study, the following measures were used and recorded for each person observed crossing the road, from the **nearside carriageway only**.

1) Age and Sex, with the age breakdown corresponding to that of the pedestrian counts.

2) Accompanied or alone.

3) Start time of crossing manoeuvre, given in hours: minutes: seconds.

4) Mode of approach to the kerb - whether the subject ran or walked to the kerb.

5) Delay at kerb (time) - recorded as minutes: seconds: 1/10th's of seconds. In addition delays at the kerb were also coded according to where the delay occurred: 1) in the gutter; 2) offside of a parked car; 3) in the effective carriageway outwith the shelter of a parked vehicle.

6) Retreat from the kerb - Yes or No.

7) Behind parked vehicle - Yes or No.

8) Delay in the centre of the road - recorded in minutes; seconds; and to the nearest 1/10 seconds.

9) Total crossing time - Total time elapsed for crossing movement from nearside kerb to farside kerb recorded in minutes; seconds; and to the nearest 1/10th's of seconds.

The following measures were recorded for **both** carriageways for each pedestrian observed crossing.

10) Mode of crossing - Run or Walk.

11) Angle of crossing - crossing angles were plotted from the video onto an enlarged map of the street section. The angle was then read from a protractor for each carriageway.

12) Acceptance gap - This was defined as the time gap between vehicles in the traffic flow in which the pedestrian decides to cross (Wilson and Grayson, 1980, P7). This was recorded in seconds and to the nearest 1/10th's of seconds.

13) Safety gaps - Two measures were defined: 1) the time from when a pedestrian steps out into the road to when the next vehicle crosses the pedestrian's path behind him/her; and 2) the amount of time each pedestrian had to spare over an approaching vehicle (Wilson and Grayson, 1980, P7). These were recorded in seconds and to the nearest 1/10th's of seconds.

Head movements on approach to the kerb and during crossing was initially examined as a measure, but rejected. Previous studies undertaken had used this as a measure of age and sex differences in crossing behaviour (Older and Grayson, 1974; Grayson, 1975; Wilson and Grayson, 1980). However, although head movement itself is an overt behaviour, it is not in actual fact a good indicator of 'good' or 'safe' crossing behaviour. Indeed, subjects may look for traffic before crossing but not see it coming as a result of poor eye sight or a momentary lapse of concentration. Also, pedestrians may not even move their heads at all before and during crossing, and eye movement, which cannot be picked up from the video, may be the only indicator of overt observation behaviour.

For the second study on Raeburn Place the measurement of safety gaps and observations relating to retreating from the kerb were omitted. Only 16 pedestrians, out of 596, in the first study were found to retreat from the kerb, while similar patterns, in relation to the distributions of safety and acceptance gaps, were found for both carriageways. It was therefore decided that in the second study, acceptance gaps only would be recorded.

The second study also sought to use more responsive micro measures of traffic conditions at the time of a pedestrian crossing. This included recording the traffic speed of the oncoming vehicle and the traffic flow at the time of crossing. Traffic flow in this case was defined, for each carriageway, as the number of vehicles within 15 seconds of the actual crossing time from the nearside kerb for the nearside carriageway, and from the centre of the road for the farside carriageway. This figure is based arbitrarily on the fact that in normal traffic conditions, it appears that vehicles over 15 seconds away have little impact generally on pedestrians crossing. This would seem to be a reasonable assumption given that studies suggest acceptance gaps over a maximum of 5 to 7 seconds are acceptable to most pedestrians (Cohen, Dearnley and Hansel, 1955; Ministry of Transport, 1965; Jacobs, Older and Wilson, 1968).

The second stage was also used to focus on the role of parked vehicles in relation to the pedestrian crossing behaviour. The initial study had found that parked vehicles were used extensively as a shield from the oncoming traffic and secondly, as a way to select more appropriate gaps in the oncoming traffic stream. Additional variables relating to the use of parked cars were therefore included in this second study. These were 1) the number of cars present in the street section at the time the pedestrian decided to cross; 2) the position of delay, if any, in relation to the parked vehicle at the time of crossing.

The variables used and recorded for each person observed crossing the road, from the **nearside carriageway only**, for the second study were:

1) Age and Sex, with the age breakdown corresponding to that of the pedestrian counts.

2) Accompanied or alone.

3) Start time of crossing manoeuvre, given in hours: minutes: seconds.

4) Mode of approach to the kerb - whether the subject ran or walked to the kerb.

5) Delay at kerb (time) - recorded as minutes: seconds: 1/10th's of seconds. In addition, delays at the kerb were also coded according to where the delay occurred: 1) on the pavement; 2) in the gutter of the road not on the pavement; 3) in the immediate shelter of the offside of a parked vehicle; 4) in the effective carriageway within 2 metres of the offside of a parked vehicle; 5) no delay at the kerb.

6) Behind parked vehicle - Yes or No.

7) Number of parked vehicles in the nearside carriageway at the time of crossing.

8) Delay in the centre of the road - recorded in minutes; seconds; and to the nearest 1/10 seconds.

9) Total crossing time - Total time elapsed for crossing movement from nearside kerb to farside kerb recorded in minutes; seconds; and to the nearest 1/10th's of seconds.

10) Crossing destination of the pedestrian, was coded as follows: 1) bus stop; 2) shops directly opposite; 3) Other: no clear destination / walking through street section - no destination; 4) parked car in the street section.

The following measures were recorded for **both** carriageways for each pedestrian observed crossing.

11) Mode of crossing - Run or Walk.

12) Angle of crossing - crossing angles were plotted from the video onto an enlarged map of the street section. The angle was then read from a protractor for each carriageway.

13) Acceptance gap - This is defined as the time gap between vehicles in the traffic flow in which the pedestrian decides to cross (Wilson and Grayson, 1980, P7). This was recorded in seconds and to the nearest 1/10th's of seconds.

3.3.2 Resident and pedestrian on-street questionnaires

Two questionnaires were devised for the initial study for both residents and on-street pedestrians in order to obtain the necessary data on pedestrian activity patterns; pedestrian and resident perceptions of the street environment and their variation by time of day; and how this may in turn affect behaviour and activity patterns by time of day. Questions that were asked fell into several sections on both questionnaires (see appendix 1 for questionnaire forms). These were: 1) personal details - age , sex, place of abode; 2) walking and activities carried out in the street; 3) street amenity; 4) assessment of traffic conditions in the street; 5) belief and value assessment (for residents only); 6) possible improvements to the pedestrian environment (for residents only).

The residents questionnaire was delivered by hand to individuals in each flat who agreed to take part in the survey along Bruntsfield Place and the number of forms dropped off were recorded on a check list. This proved useful in increasing the sample size when the questionnaires were collected, as those households which had not been contacted were readily identifiable from the checklist. A maximum of 4 unsuccessful visits to each household was used as the threshold before the address was abandoned and excluded from the survey. The on-street questionnaire was carried out over 3 days by a team of trained interviewers who had been familiarised with the questionnaire format and the way in which responses were to be elicited from respondents. Each individual member of the team was given a target number of interviews for each age group which had to be completed within the selected analysis periods. These were (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000. However, the desired targets proved hard to achieve over the 3 allocated days. Firstly, due to the low numbers on street in the under 18 and over 65 age groups, and secondly, due to the adverse weather conditions at the time of survey.

For the second study, only a resident survey was used due to the fact that responses from both the resident and on-street surveys in the initial study were similar. A resident survey also guarantees a higher quality of response due to the fact that residents will be able to spend more time on their forms and subsequently, the level of detail to the responses will be greater than that which could be obtained on-street. In order to increase information on the elderly, in the second study, forms were also delivered to Stockbridge House on

Cheyne Street run by the Edinburgh and Leith Old Peoples' Welfare Council (see figure 3.3).

For the second study, the questionnaire form was modified to address particular aspects of crossing behaviour. This involved the collection of more detailed information highlighting:

1) the problems associated with the traffic conditions and crossing the road;

2) origins and destinations of pedestrian routes and trip diversions;

3) crossing strategies with questions referring to actual performance rather than knowledge of safe behaviour.

A supplementary diary survey was considered but discounted on the basis that the additional information obtained could not be justified, given the principal problems associated with diary surveys. These are that a lot of work is asked of the respondent and it is often difficult to gain cooperation from the selected sample; that diary surveys are more expensive; and that the standard of respondents recording may not be as accurate as hoped for, since respondents often forget to record information while it is still fresh in their mind.

3.3.3 In-depth interviews

In-depth individual interviews were undertaken to complement the on-street and residential questionnaire surveys. These were designed to explore issues which the questionnaire survey had not fully dealt with including:

1) the lack of data on the link between perceived traffic levels and of risk, and behavioural response and perceptions of safety and risk;

2) the constraints of the set questionnaire format; and

3) the inability to get closer to an individual's experience and the way in which they account for this in their own words.

In general the aim in using in-depth interviews was to obtain different qualitative data to increase the ability to interpret questions relating to perception. The interviews were based on the interview guide approach (Patton, 1990). An interview guide is a list of questions that are explored in the course of the interview. The guide was devised to ensure that the information obtained from a number of people covers the same ground (appendix 1). The interview guide also enables the interviewer to probe and explore issues that will elucidate and illuminate that particular subject (Patton, 1990, P283). Nonetheless it leaves the respondents to express their views and experiences in their own words rather than in preconceived categories devised by the researcher. The advantages of this approach are that:

1) the interviewer has decided how best to use the limited time available in the interview;

2) it helps to make interviewing across a number of different people more systematic and comprehensive by delimiting in advance the issues to be explored;

3) logical gaps in the data can be anticipated and closed;

4) interviews remain conversational and situational; and

5) responses are not limited to pre-determined response categories. The use of an in-depth qualitative interview approach ensures that responses are in no way constrained.

Each of the interviews lasted approximately 30-40 minutes and were conducted by the author. For the purposes of this study, all interviews were tape recorded. It was felt that any attempt to make verbatim notes would seriously affect the interactive nature of the interview. Following completion of the interviews, all tapes and field notes were transcribed and collated by the author. Three groups were interviewed in this way: young adults, the elderly, and primary school children.

Individuals within each age group were selected on the basis of having prior knowledge and experience of being a pedestrian on Raeburn Place. To ensure that this requirement was fulfilled, the elderly were selected from sheltered and rented housing on Raeburn Place and in adjacent streets, while the children interviewed were selected from the nearest local primary school to Raeburn Place. The young adults selected for interview were obtained from the pool of students who had earlier helped with the video study of pedestrian behaviour on Raeburn Place. These students had been involved in looking after the video equipment for security reasons whilst filming was taking place.

Young adults

This group was drawn from students aged 22-23 years old on the undergraduate planning course in the School of Planning and Housing at the Edinburgh College of Art/Heriot-Watt University. The students were encouraged to participate on the basis that it would be a useful experience for them before they undertook their own research work for their dissertations. Six students were interviewed and the responses were generally of a high quality. This may reflect a greater than normal level of awareness in terms of transport and road safety issues, some of the students having studied transport planning as part of their planning degree course. However, many of those interviewed admitted that they had not really thought through their pedestrian experiences sufficiently and that the interview had made them think.

The elderly

Interviews with the elderly, aged 66-87 years old, were held at the Stockbridge Day Centre which is run by the Edinburgh and Leith Old People's Welfare Council. The day centre staff were very helpful and were very interested in the project. The day centre administrator, a very active and forthright individual, was particularly interested in the project due to the fact that a number of the day centre users lived in sheltered and rented accommodation along and adjacent to Raeburn Place. The administrator's co-operation was essential for these interviews as the participants were principally at the day centre for their lunches and for activities such as indoor bowling and dancing. She also helped to ensure a steady supply of willing interviewees. A television room in the centre was provided in which the interviews could take place without interruption, although several of those who attended the day centre, who came into the room for a smoke and to watch the television were upset that they could not stay in the room while the interviews were taking place. Eight interviews were conducted over two days (Thursday 2nd and Wednesday 15th June).

Primary school children

After a long period waiting for permission to be granted, an encouraging response was obtained from Lothian Regional Council's Education Department and permission was given to interview primary school children aged 9-10 years at the Stockbridge Primary School. The Road Safety Development Officer who works within the Department was very keen that the interviews were undertaken. Problems were however encountered with the selected school where the Headmistress was very unwilling to co-operate with providing the children for interviews. This unwillingness was intimated to me and the Road Safety Development Officer on several occasions.

The uneasy situation was also apparent at the school and the situation could at best be described as "cool". A fourth floor room was made available where the interviews could take place, this was particularly unsuitable due to the monitor and video equipment which needed to be carried up to this room. The interview room also encountered noise from adjacent school rooms and the interviews were prone to interruption by teachers and pupils passing through. Other problems arose on the first day of interviewing, when during the second interview the headmistress wanted the pupil to go to morning break, the time of which I had not been given. At this point she also informed me that as part of their sport's day had been rained off, the interviews would have to be cut short. Despite these problems seven interviews were successfully undertaken.

Interview design

The interview design consisted of three parts. Initially the interview revolved around general questions relating to age, health, mobility and travel patterns. This served to orientate the interview and provided the necessary background to the characteristics of pedestrian travel experiences generally, and factors which affect pedestrian behaviour and movement. The second section in the interview consisted of a threshold assessment exercise where respondents, while watching a specially edited video tape, were asked to state when they thought the traffic flow "ceased to be light" and when it "started to get heavy". This was used to gain further insight into the levels at which traffic was perceived to be "light" and "heavy" in accordance with an objective measure of traffic flow, obtained from the video. This data was also used to study variations in the assessment of traffic flow within each age group. The third section of the interview combined the use of selected excerpts of video tape which were edited to specifically show five different traffic conditions. Questions relating to crossing behaviour and perceptions of safety were asked after each excerpt had been shown. This sought to further explore the links between perceived traffic levels and perceptions of safety and risk, and behavioural response.

In the threshold assessment exercise, interviewees were played a specially edited continuous tape, lasting three minutes, in which traffic was seen to gradually increase in volume on Raeburn Place. After watching the tape for the first time, the tape was rewound and the interviewees were asked to indicate when they felt that the traffic was no longer light, at this point the tape was stopped and the timing was recorded from the video counter. The tape was then restarted and respondents were then asked to indicate when they thought the traffic was heavy. Respondents often found this task problematic due to the platooning which often occurred in certain excerpts. For intermediate (medium) flow levels, platooning was found to result in a combination of light and heavy traffic flow conditions in a given 15 second excerpt of tape. Due to this problem, it was decided that a dialogue/conversation would be maintained with the interviewee during the showing of the continuous tape in an attempt to overcome the nervous silences which accompanied this section of the interview at the start. This also encouraged the interviewee to interact more and helped to improve the quality of the response in relation to what was being shown on the video monitor. This approach was particularly useful when interviewing both the elderly and primary school children.

The third section of the interview design was also based on an innovative approach which combined the use of selected excerpts of video tape which were edited specifically to show different traffic conditions. Each traffic flow level was chosen to broadly reflect those categories used in the analysis of pedestrian behaviour. This approach sought to place the interview within some context and was also seen as a way of maintaining interest in the interview. The five excerpts were :

1) Heavy traffic flow - 6-9 vehicles per 15 seconds;

2) Congested traffic flow in both carriageways - build up of stationary vehicles in both carriageways (over 9 vehicles per 15 seconds);

3) Congested traffic flow in one carriageway - build up of stationary vehicles in one carriageway (over 9 vehicles per 15 seconds) and a medium level of traffic flow in the other carriageway (3-6 vehicles per 15 seconds);

4) Medium traffic flow - 3-6 vehicles per 15 seconds;

5) Light traffic flow - 0-3 vehicles per 15 seconds.

The same questions for each excerpt were used and were aimed at eliciting responses relating to perceptions of traffic and street conditions in each excerpt to feelings of safety and risk, and crossing behaviour. These included questions relating to:

1) crossing the road and choice of crossing location;

2) the impact of journey importance on decisions to cross and crossing location;

3) the rescheduling of journeys and alternative crossing strategies;

4) feelings evoked by the street/traffic environment portrayed in the video; and

5) aspects of the street environment which promoted these feelings.

3.4 DATA ANALYSIS

Data from both video and set-format questionnaire studies was mounted on the VAX VMS mainframe computer and the analysis was undertaken using the SPSSX package for social sciences. In addition, graphics were produced on the Harvard Graphics package. Analysis of the questionnaire studies was undertaken using the Chi-square statistical test for assessing the level of association between two variables. Data from the pedestrian behaviour video study was analysed initially using correlation and the Chi-square test to identify the more relevant relationships. These relationships were in turn analysed further using multiple regression. All results referred to are significant at or above the 95% level.

The qualitative data derived from the personal in-depth interviews was transcribed from the tape recordings and analysed using inductive analysis. Patterns, themes and categories identified, emerged from the data rather than being imposed prior to data collection and analysis.

Table 3.1 Study Methodology - Differences Between the Two Studies.

Methodology	Bruntsfield Place	Raeburn Place
Video Study	Tape coverage 0800-2000 for one day Pedestrian flow counts Traffic flow counts Traffic speed for analysis periods: (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000 Pedestrian behaviour observations for one side of street between 0800-2000	Tape coverage 0800-2200 for three days Pedestrian flow counts Traffic flow counts Traffic speed for analysis periods: (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000 (5) 2030-2200 Pedestrian behaviour observations structured sample to gain adequate number of observations for under 18 and over 65 age groups retreat from kerb and safety gaps omitted micro measures relating to traffic speed and flow at the time of crossing collected additional variables relating to the use of parked cars in the crossing task included
Questionnaire Study	On-street survey Residents survey	No on-street survey Residents survey additional questions included relating to: (1) problems associated with crossing the road and traffic conditions (2) crossing strategies and the use of parked cars questions on stress and risk withdrawn
In-depth Interviews	No in-depth interviews	In-depth interviews of young adults, primary school children and the elderly. 1) Helped to avoid set format of previous questionnaire 2) Interviews combined with video to link perceptions of traffic with experience under certain conditions

CHAPTER 4 ANALYSIS OF RECORDED OBSERVATIONS OF PEDESTRIAN CROSSING BEHAVIOUR

4.1 INTRODUCTION

The concept of the traffic barrier has been explored and defined in chapter 1. It has been indicated that the traffic barrier concept refers to a set of traffic conditions within a specified street environment (context) and the perceptions of those conditions. The traffic barrier effect is manifested by pedestrians' observable behavioural response - a response which is mediated by perceptions. This chapter reports on the analysis of observed pedestrian crossing behaviour on the case study streets, and the changing nature of that response as a function of changes in traffic conditions (traffic flow and speed levels). Later chapters (5 and 6) discuss other elements of the study - the set format questionnaire surveys and personal in-depth interviews - which seek to address perceptions of the street and traffic environment.

In seeking to achieve a better understanding of the operation and function of the traffic barrier, this chapter, through the analysis of observations of pedestrian crossing behaviour, assesses the following hypotheses which were outlined in chapter 3:

1) the extent to which the traffic barrier effect on pedestrian behaviour is determined by actual traffic flow levels;

2) the relative importance of traffic flow and speed as indicators of pedestrian behaviour;

3) the role of kerbside parking in mediating the traffic barrier effect.

Following a description of the traffic conditions and pedestrian activity levels this chapter reports on findings from the video studies of pedestrian crossing behaviour undertaken on both Bruntsfield Place and Raeburn Place as part of this study. The behavioural analysis approach using video in this study has been outlined in chapter 3. Following a description of the age and sex characteristics of the samples used, results relating to the analysis of pedestrian behaviour are discussed in the following order:

1) walking situation;

2) mode of approach;

3) pedestrian delay

4) acceptance gaps;

5) crossing angles;

6) mode of crossing;

7) delay in the centre; and

8) crossing from behind parked vehicles.

For each section the data is initially analysed at the aggregate level and then is disaggregated by age. Bivariate data analysis, using the Pearsonian correlation coefficient was also undertaken to assess the relationships between other behavioural measures. This analysis was then disaggregated by age, sex and walking situation. Analysis of the data using the Pearsonian correlation coefficient was also supplemented by crosstabulations of data using the Chi-square test. Multivariate analysis using regression was also undertaken to examine the relative importance of traffic speed and traffic flow conditions on Raeburn Place for pedestrian crossing behaviour. Finally, changes in pedestrian crossing patterns were assessed using a measure called the crossing ratio: a ratio expressed as the proportions of pedestrians crossing as a percentage of total flow on respective pavements.

4.2 TRAFFIC AND PEDESTRIAN ACTIVITY

This section describes the aggregate traffic flow and speed conditions found on Bruntsfield Place and Raeburn Place at the time of the video studies of pedestrian crossing behaviour. Patterns of pedestrian activity for different age groups through the day on both Raeburn Place and Bruntsfield Place are also outlined. This analysis does not relate directly to the analysis of pedestrian crossing behaviour but highlights the overall pattern of traffic and pedestrian activity on the days on which these studies were undertaken. It provides a general picture of traffic conditions and their variation through the day. Although variations in traffic flow and speed are evident, the general trends described here are of only limited relevance when discussing the likely effects of traffic flow and traffic speed directly on pedestrian behaviour. Average speed and flow may, however, have impacts on unobserved pedestrian behaviour where assumptions about traffic conditions are internalized by individuals. The analysis of pedestrian crossing behaviour using video data which relates directly to specific traffic speed and flow conditions at the time of crossing is presented later in this chapter in section 4.3.

4.2.1 Traffic flow

Bruntsfield Place

The traffic flows recorded along Bruntsfield Place indicate the strong centripetal pull of the central area of Edinburgh (see figure 4.1). Northbound journeys are substantially higher in the a.m. peak up to 0945 with recorded flows fluctuating between 294 vehicles per 15 minutes at 0815 and 159 vehicles per 15 minutes at 0945, compared to 110 vehicles per 15 minutes at 0815 and 128 vehicles per 15 minutes at 0945 southbound. The reverse is true in the p.m. peak, when south bound (outward bound) journeys are higher from 1530 to 1800 with 156 to 226 vehicles per 15 minutes compared to that northbound of 127 to 164 vehicles per 15 minutes. For the intermediate period (from 0945 to 1530) traffic flows are remarkably stable for both directions, with recorded flows in the region of 150 to 200 vehicles per 15 minutes.

Total vehicular flows are substantial given that the road passes through a densely populated residential area. Total northbound flow recorded was 8111 vehicles for the 12 hour period, while for southbound, total flow was lower at 7577 vehicles. This gives a total flow for both directions of 15688. The average flows for the 15 minute periods over the 12 hours were 169 vehicles per 15 minutes northbound, and 158 vehicles per 15 minutes south bound; giving an average figure for both directions of 327 vehicles per 15 minutes.

Figure 4.1 Traffic Flow, Bruntsfield Place.

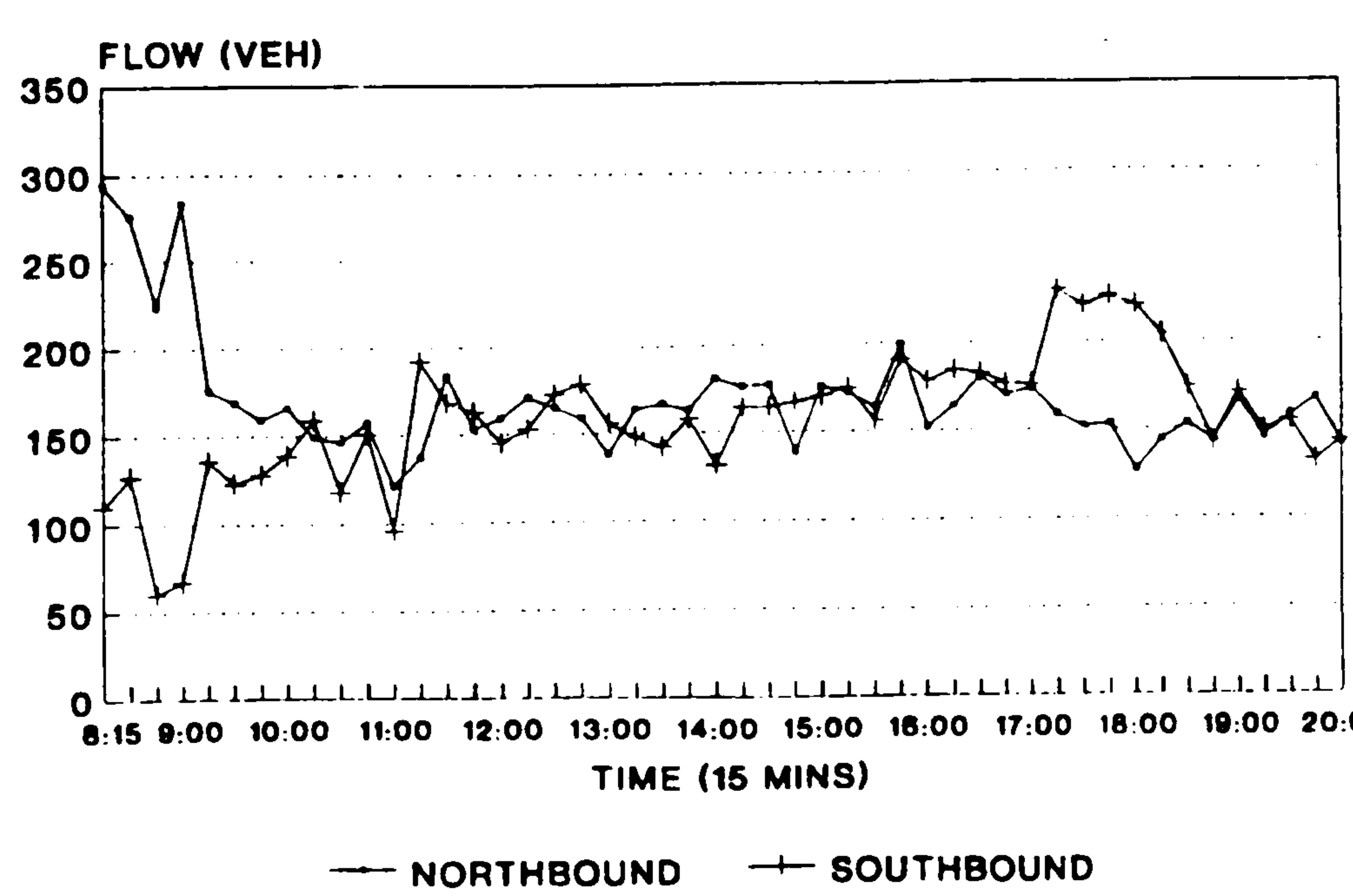
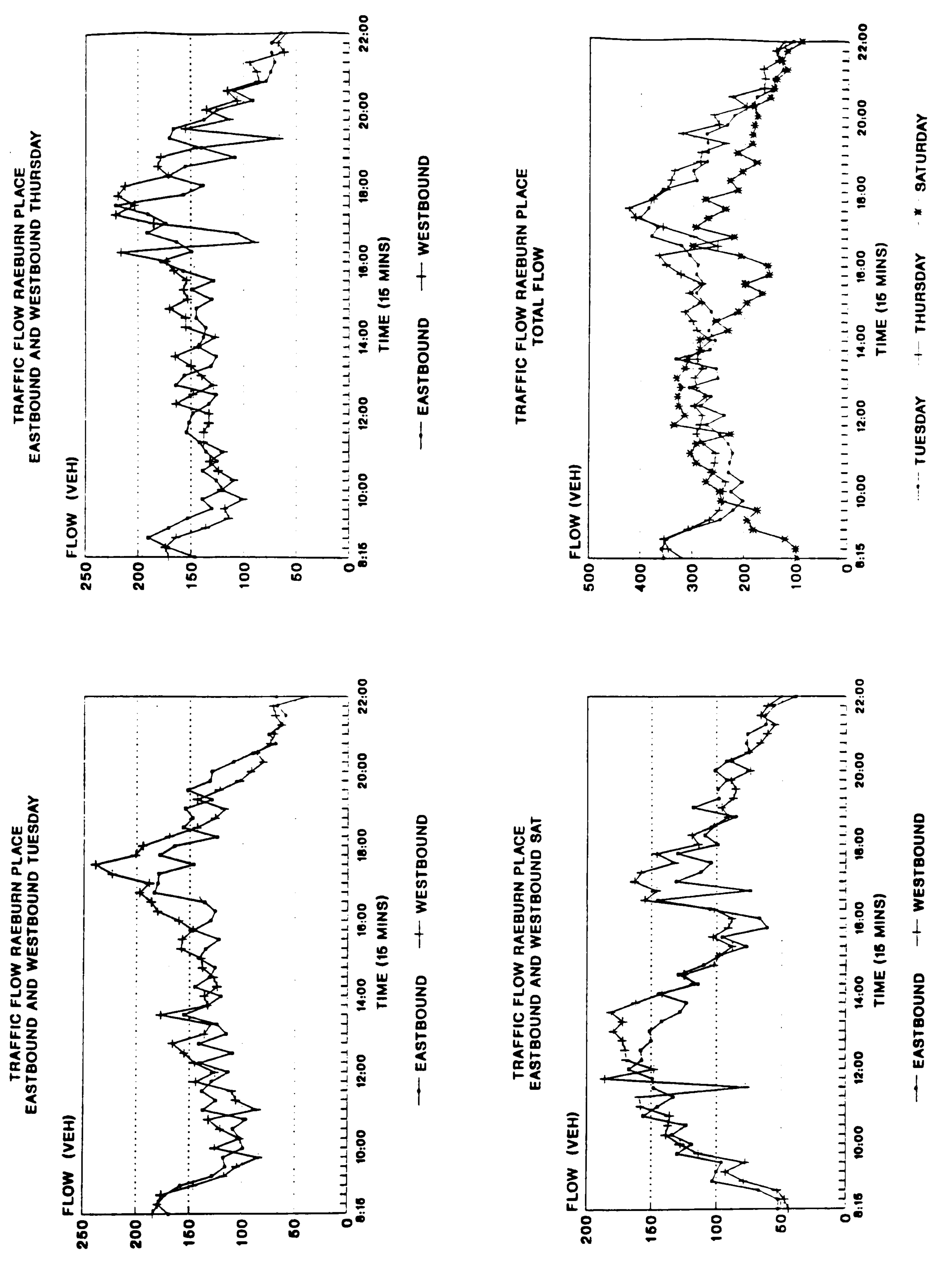


Figure 4.2 Traffic Flow, Raeburn Place.



Raeburn Place

For Raeburn Place, traffic flows from 0800-2200 were recorded over 3 days in October 1991: Tuesday 22nd, Thursday 24th and Saturday 26th. Traffic flow profiles are remarkably similar up to around 1600 on both Tuesday and Thursday (figure 4.2). Total vehicular traffic flows on Raeburn Place for 12 hours, up to 2000, are slightly lower than on Bruntsfield Place. On Tuesday, total 12 hour vehicular flows, up to 2000, were 6615 eastbound and 6995 westbound, while on Thursday, 12 hour total flows were higher than for Tuesday but still lower than those recorded for Bruntsfield Place: up to 2000, 7181 eastbound and 7169 westbound. Traffic flow data for Saturday reveals a lower 12 hour total flow figure of 5483 vehicles eastbound and 5795 vehicles westbound up to 2000.

From figure 4.2, it is clear that during the morning peak period, east and westbound flows are at a slightly higher level initially at around 0800 on Tuesday by comparison to traffic flows on Thursday. Eastbound flows on Thursday however, appear to peak slightly later at around 0845. Up to around 0945 east and westbound flows, on both Tuesday and Thursday, decline and then increase gradually, stabilizing at the 100-150 vehicles per 15 minutes flow level until the late-afternoon/early-evening peak at around 1630 on Thursday and 1645 on Tuesday. By comparison, both east and westbound traffic flows on Saturday increase to much higher levels during the midday period, 1200-1400, than during the weekdays. Traffic flows for all 3 days then decline until around 1600. During the weekdays from 1600 onwards, the increase in traffic flows is associated with the evening peak return journey from work. For Saturday, this peak is associated with leisure and shopping activity.

4.2.2 Traffic speed

Bruntsfield Place

Traffic speed data was only recorded for the 4 analysis periods (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000 and was obtained using the random sample method as advocated by Almond (1963). Tables 4.1a and 4.1b reveal that the average mean speed recorded is higher in the southbound lane where there is lighter traffic flow for the period 0800-0915 (42 km/h [standard deviation 9km/h] compared to 33 km/h [standard deviation 11km/h] in the northbound lane). There is evidence from the video which would suggest these lower speeds may be the result of the bus stop in the northbound carriageway and/or the platooning of the traffic as a result of the traffic light controlled intersection, to the south of Bruntsfield Place. The average mean speeds for analysis periods (2) 1130-1330 and (3) 1500-1730 reflect the stable traffic flow conditions existing at these times in both north and southbound carriageways, with mean average speeds in the northbound carriageway for the respective periods being 31.58 km/h (standard deviation 10.49 km/h) and 32.81 km/h (standard deviation 10.47) and in the southbound 33.03 km/h (standard deviation 9.05 km/h) and 33.21 km/h (standard deviation 8.85 km/h). By comparison, the lower traffic flow conditions existing in analysis period (4) 1845-2000 create conditions in which average mean speeds in both carriageways increase to 39 km/h northbound (standard deviation 9.24 km/h) and 41.2 km/h southbound (standard deviation 7.44 km/h).

Table 4.1a Traffic Speeds Northbound, Bruntsfield Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum Speed (kmh)	Minimum Speed (kmh)
0800-0915	197	33.5	11.4	67.5	5.1
1130-1330	224	31.6	10.5	50.6	5.3
1500-1730	306	32.8	10.5	67.5	6.5
1845-2000	174	39.0	9.2	67.5	9.6

Table 4.1b Traffic Speeds Southbound, Bruntsfield Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum Speed (kmh)	Minimum Speed (kmh)
0800-0915	154	41.8	9.3	67.5	22.5
1130-1330	229	33.0	9.0	50.6	9.6
1500-1730	327	33.2	8.6	56.3	3.4
1845-2000	174	41.2	7.4	63.3	11.3

Raeburn Place

Traffic speed data for Raeburn Place was similarly recorded from the video for 5 analysis periods (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000 (5) 2030-2200. Data was recorded for Thursday and Saturday only. For Raeburn Place, as well as mean average speeds and measures of the spread, frequency distributions and 85th percentile speeds are also analysed.

On Thursday, a large proportion of traffic speeds recorded eastbound and westbound were over 30 km/h. Periods associated with particularly large proportions of high speeds and low traffic flow levels are 0800-0915, 1845-2000 and 2030-2200 (see appendix 4 for speed distributions by time period). 85th percentile speeds reveal that for these time periods 85% of vehicles were travelling at speeds of up to 46.1 km/h in both carriageways (tables 4.2a and 4.2b).

Average mean speed data is strongly linked with traffic flow conditions. For Thursday, data from 0800 to 0915 revealed that average mean speeds eastbound were lower than those westbound, 35.9 km/h (standard deviation 9.56 km/h) compared to 39.5 km/h (standard deviation 7.72 km/h) (tables 4.2a and 4.2b). This difference may be due to the higher levels of eastbound traffic flow, towards the city centre, in the a.m. peak. For analysis periods 1130-1330, 1500-1730 and 1730-1845 speeds are much lower than in the first analysis period, reflecting the higher levels of traffic flow and also the results of platooning the traffic flow at other junctions to the east and west of Raeburn Place. Speeds in both carriageways for these time periods are around 27-28 km/h. From 1800 in Raeburn Place, traffic flow levels begin to lower and this is reflected in the respective rise in speeds both east and westbound for analysis periods 1845-2000 and 2030-2200 (tables 4.2a and 4.2b).

The traffic speed frequency distribution for Saturday covers a somewhat larger range than that for Thursday (see appendix 4 for speed distributions). Periods covering 0800-0915 and 2030-2200, both east and westbound, are associated with particularly high speeds, while much lower speeds are associated with the more congested and higher traffic levels over the midday and early afternoon period. These patterns are also reflected in the high 85th percentile speeds and average speeds, especially eastbound for the periods 0800-0915 and 2030-2200 (figures 4.3a and 4.3b).

Table 4.2a Traffic Speeds Eastbound, Thursday, Raeburn Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum (kmh)	Minimum (kmh)	85th Percentile (kmh)
0800-0915	172	35.9	9.6	57.6	12.1	46.1
1130-1330	213	28.2	9.7	57.6	7.4	38.4
1500-1730	277	27.6	10.8	57.6	5.8	38.4
1845-2000	127	37.6	10.3	76.8	17.7	46.1
2030-2200	118	41.5	8.3	57.6	23.0	46.1

Table 4.2b Traffic Speeds Westbound, Thursday, Raeburn Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum (kmh)	Minimum (kmh)	85th Percentile (kmh)
0800-0915	172	39.5	7.7	57.6	23.0	46.1
1130-1330	235	27.2	7.6	57.6	7.4	32.9
1500-1730	329	28.1	6.4	46.1	11.5	32.9
1845-2000	148	34.9	8.4	76.8	17.7	46.1
2030-2200	87	31.8	6.8	46.1	19.2	38.4

Table 4.3a Traffic Speeds Eastbound, Saturday, Raeburn Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum (kmh)	Minimum (kmh)	85th Percentile (kmh)
0800-0915	91	43.2	11.1	76.8	14.4	57.6
1130-1330	143	19.4	11.4	57.6	2.9	32.9
1500-1730	202	29.7	10.3	57.6	6.6	38.4
1845-2000	105	41.6	9.8	76.8	14.4	47.2
2030-2200	103	45.7	9.5	76.8	23.0	57.6

Table 4.3b Traffic Speeds Westbound, Saturday, Raeburn Place.

Analysis Period	Sample Number of Vehicles	Mean Average Speed (kmh)	Standard Deviation (kmh)	Maximum (kmh)	Minimum (kmh)	85th Percentile (kmh)
0800-0915	82	36.7	9.7	57.6	20.6	46.1
1130-1330	186	23.2	7.5	38.4	6.4	32.9
1500-1730	224	29.1	9.0	76.8	9.6	38.4
1845-2000	104	30.5	6.6	46.1	17.7	38.4
2030-2200	96	36.0	8.4	57.6	20.9	46.1

4.2.3 Pedestrian Activity

The video analysis of pedestrian activity patterns (as described in chapter 3) indicated that most pedestrian activity was associated with adults. Child pedestrian activity represents below 7% of total flow for each pavement on Raeburn Place and Bruntsfield Place. This is also reflected in the low proportion of child pedestrian casualties found on tenemental-radial routes. Flow levels for pedestrians aged over 65 are similarly low, below 10% on both Raeburn Place and Bruntsfield Place. These patterns of activity are also clearly reflected in the questionnaire study findings (see chapter 5). The elderly are infrequent trip makers as pedestrians; 40.4% of those aged over 65 in the Raeburn Place survey stated that they only made up to 2 trips a week as a pedestrian along Raeburn Place. However, most of those residents surveyed indicated that they walked along Raeburn Place and Bruntsfield Place on a relatively frequent basis.

Most pedestrian trips along Bruntsfield Place and Raeburn Place are associated with essential activities. Primarily these are: shopping, trips to or from work, and trips to or from school or college. Only a small proportion of journeys are associated with other activities. On both streets, the generation of pedestrian activity is linked to the amount and type of retail activity located on each pavement. Higher levels of pedestrian activity are associated with more intensive retail land uses on the western pavement in Bruntsfield Place, and the northern pavement in Raeburn Place.

Male pedestrian activity is relatively high during the initial morning period and early evening periods, at around 0800-1000 and 1900-2000 on Bruntsfield Place, and between 0800-0900 and at around 1745 on Raeburn Place. This appears to correspond with peaks associated with travelling to and from work. By comparison, female pedestrian activity is dominant outwith these peaks, peak activity for females occurs between 1100-1400 and 1500-1630 (figure 4.3a-b and appendix 3). These differences could reflect factors such as:

a) more women are in part-time work or are based in the home. This allows more flexibility, resulting in a less marked peaking effect by comparison to male activity patterns;

b) the female peak over the midday and afternoon periods could be ascribed to women using the street more intensively for shopping;

Crossing activity reflects these flow patterns. Crossing flows are dominated by the adult (18-65) age group. Male pedestrian crossing activity during the week is found to be at a higher level in the morning period up to around 1000, while female crossing activity is associated with periods around 1000 to 1100, 1300-1430, and 1500-1600. Crossing activity on Saturday is dominated by male pedestrians up to midday, whilst during the rest of the day, male and female crossing activity are at similar levels (appendix 3).

Figure 4.3a Pedestrian Flow, Eastern Pavement, Bruntsfield Place by Sex.

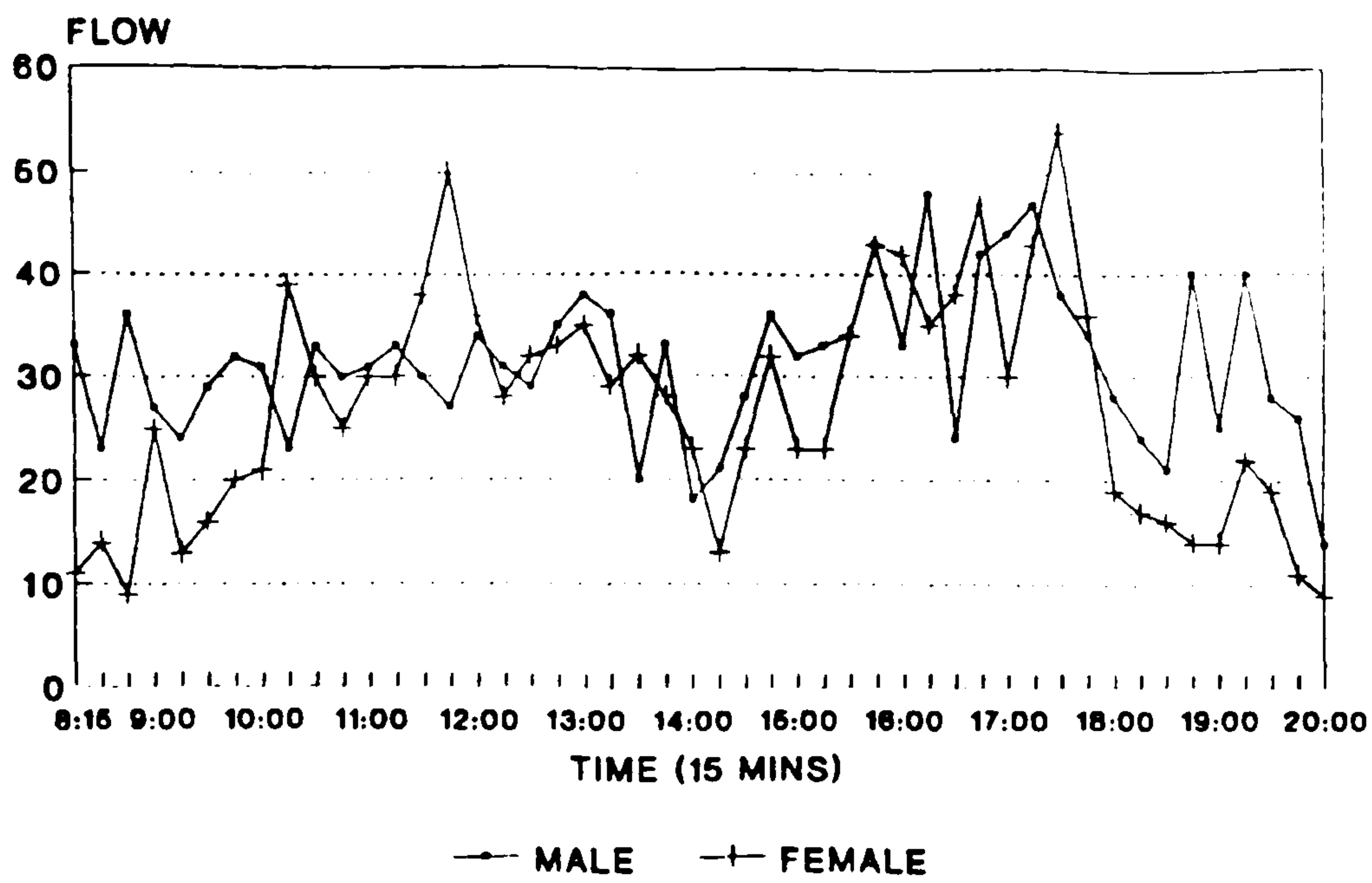
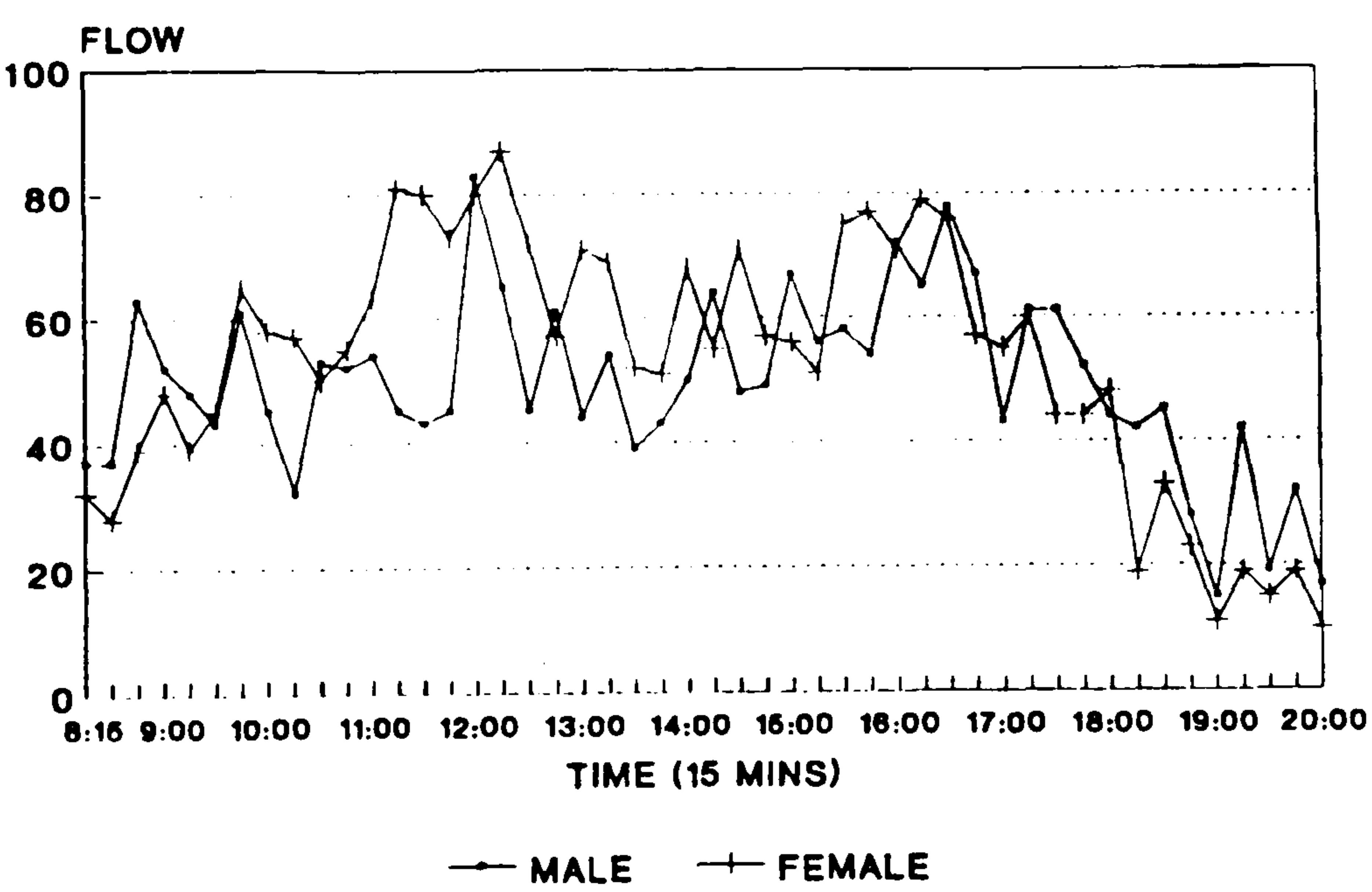


Figure 4.3b Pedestrian Flow, Western Pavement, Bruntsfield Place by Sex.



4.3 BEHAVIOURAL MEASURES - THE RESULTS

For the purposes of the Bruntsfield Place study, for reasons explained in chapter 3, the analysis of behaviour was undertaken for crossing manoeuvres occurring from the western side of the street. There was a total of 596 observations over the 12 hour period between 0800 and 2000. For the Raeburn Place survey a different approach was adopted. This involved taking a systematic stratified sample of 515 observations, ensuring that the 3 age groups identified were adequately represented.

Following discussion of the aggregate data and disaggregations by age and sex, relationships between the behavioural measures are assessed using the Pearsonian correlation coefficient and crosstabulations using the Chi-square test. For the discussion of pedestrian delay and acceptance gaps the analysis also includes a multi-variate regression analysis.

4.3.1 Age and sex characteristics

Table 4.4 shows the age and sex breakdown of the sample of pedestrians from which measures of pedestrian crossing behaviour were obtained in both surveys. The Bruntsfield Place sample is dominated by the adult age groups and accounted for 89% of all females and 94% of all males (proportions are not expressed in table 4.4).

Table 4.4 Age and Sex Characteristics, Bruntsfield Place and Raeburn Place Surveys.

	Bruntsfield Place		Raeburn Place	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Child	6 1	6 1	57 11	99 19
Adult	315 53	232 39	83 16	96 19
Elderly	14 2	23 4	63 12	117 23

4.3.2 Walking situation

On both Raeburn Place and Bruntsfield Place a substantial proportion of pedestrians crossed the street unaccompanied: 78.7% on Bruntsfield Place and 65.4% on Raeburn Place (table 4.5). Further analysis of data from both streets also revealed that walking situation is dependent on age. Levels of accompaniment are particularly high for children; 64.7% and 83.3% were accompanied when crossing the road (table 4.6). In other studies higher levels of accompaniment for children, and to a certain extent the elderly, have been shown to be associated with barrier effects: the perceived threat of traffic, and relatively higher levels of crossing difficulty on heavily trafficked routes.

Table 4.5 Walking Situation, Bruntsfield Place and Raeburn Place.

Walking Situation	Bruntsfield Place	Raeburn Place
Sample Number[1]	*596* %	*515* %
Alone	78.7	65.4
Accompanied	21.3	34.6

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.6a Walking Situation and Age, Bruntsfield Place.

Age	Sample Number[1]		Alone	Accompanied
Under 18	12	%	16.7	83.3
18-65	547	%	80.3	19.7
Over 65	37	%	75.7	24.3

Note
[1] Sample number refers to number of pedestrians.

Table 4.6b Walking Situation and Age, Raeburn Place.

Age	Sample Number[1]		Alone	Accompanied
Under 18	156	%	35.3	64.7
18-65	179	%	83.8	16.2
Over 65	180	%	73.5	26.7

Note
[1] Sample number refers to number of pedestrians.

As expected, a significant relationship was also found to exist between walking situation and time period on Bruntsfield Place (table 4.7). Although the sample is dominated by those crossing alone throughout the day, accompaniment increases during the time periods 1130-1330, 1500-1730, and 1845-2000 (29.9%, 26.8%, 14.2% of the sample at those times). These are periods during which traffic levels are relatively high corresponding with periods during the day associated with lunch; when parents are accompanying children; when friends are walking in groups to or from school or college; with groups shopping; and groupings associated with recreational or leisure activities in the evenings.

Table 4.7 Walking Situation and Time of Day, Bruntsfield Place.

Time Period *Sample Number*[1]	Alone *469* (%)	Accompanied *127* (%)
0800-0915	5.3	0.8
0915-1130	14.9	9.4
1130-1330	22.8	29.9
1330-1500	14.5	11.0
1500-1730	26.9	26.8
1730-1845	10.4	7.9
1845-2000	5.1	14.2

Note
[1] **Sample number refers to number of pedestrians.**

4.3.3 Mode of approach to the kerb

Observations were obtained concerning mode of approach to the kerb i.e whether the pedestrian ran or walked to the kerb. The overwhelming majority of pedestrians walked to the kerb; 98.7% in Bruntsfield Place and 99.6% in Raeburn Place (table 4.8).

Table 4.8 Mode of Approach to Kerb, Bruntsfield Place and Raeburn Place.

Mode of Approach *Sample Number*[1]	Bruntsfield Place *596* %	Raeburn Place *515* %
Walk	98.6	99.6
Run	1.4	0.4

Note
[1] **Sample number refers to number of pedestrians.**

Although the proportions running to the kerb are low in both streets, the proportion is significantly higher on Bruntsfield Place. The greater amount of running activity on Bruntsfield Place is presumed to reflect the higher proportion of adult pedestrians and relatively smaller acceptance gaps than on Raeburn Place. On Bruntsfield Place running activity is particularly linked with pedestrians who are accompanied (table 4.9a-b).

Table 4.9a Walking Situation and Mode of Approach, Bruntsfield Place.

Walking Situation	Sample Number[1]		Walk to Kerb	Run to Kerb
Alone	469	%	99.1	0.9
Accompanied	127	%	96.9	3.1

Note
[1] Sample number refers to number of pedestrians.

Table 4.9b Walking Situation and Mode of Approach, Raeburn Place.

Walking Situation	Sample Number[1]		Walk to Kerb	Run to Kerb
Alone	337	%	99.4	0.6
Accompanied	178	%	100.0	0.0

Note
[1] Sample number refers to number of pedestrians.

4.3.4 Pedestrian delay

Overall there is a wide range of delays experienced by pedestrians on both case study streets: from a minimum of 1.00 second to a maximum of 54.5 seconds on Bruntsfield Place and from a minimum of 1.6 seconds to a maximum of 56 seconds on Raeburn Place. The average delay on Raeburn Place is 3 seconds greater than that experienced on Bruntsfield Place (see appendix 4). This is due to age composition, rather than factors attributed to differences in street environments, with larger proportions of the young and elderly in the Raeburn Place sample. This is well illustrated by the frequency distribution of delays, with 53.8% of delays on Raeburn Place lasting 0-5 seconds compared to 63.4% on Bruntsfield Place (table 4.10).

Table 4.10 Distribution of Pedestrian Delays, Bruntsfield Place and Raeburn Place.

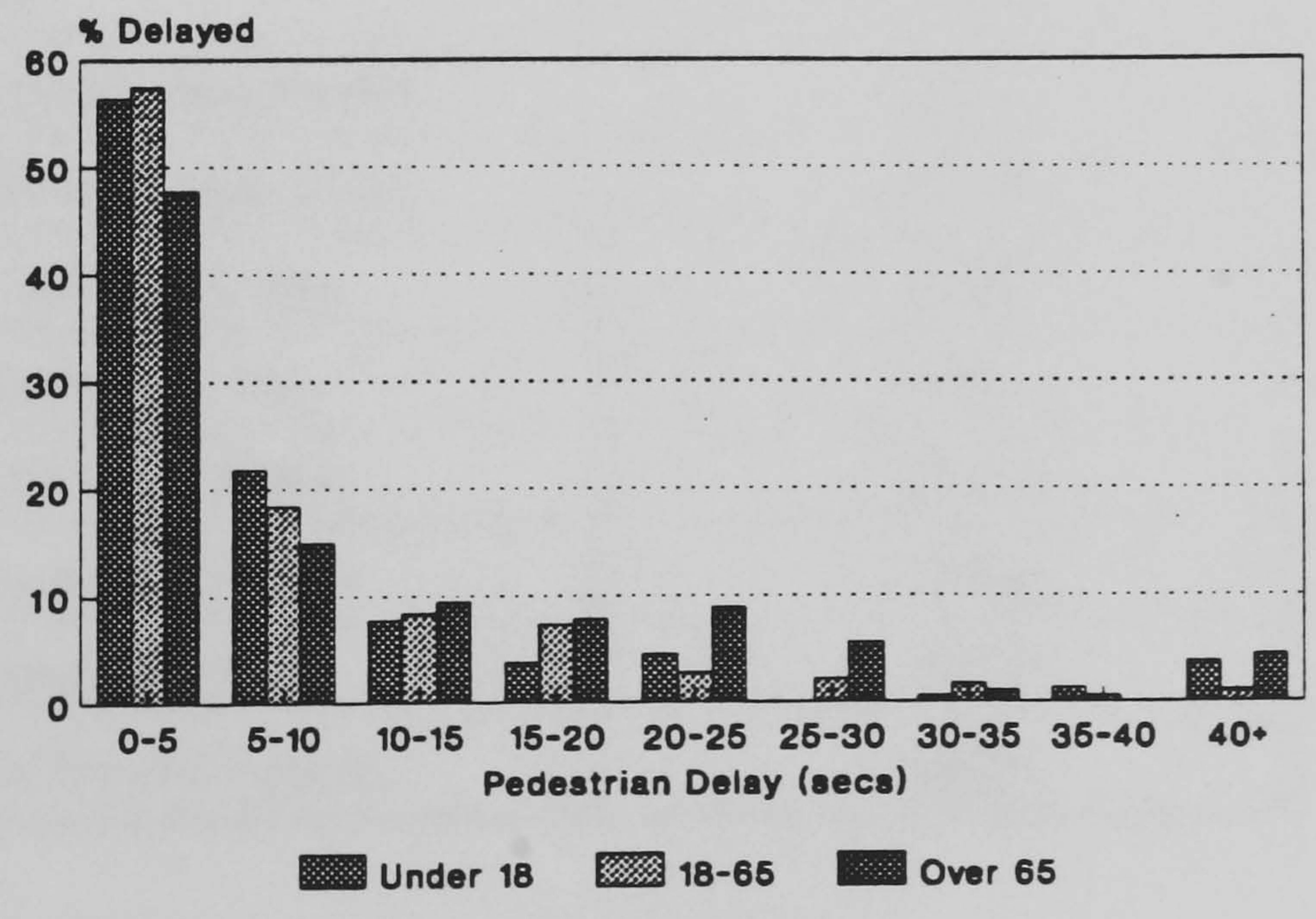
Pedestrian Delay (secs) ***Sample Number*[1]**	**Bruntsfield Place** ***596*** *%*	**Raeburn Place** ***515*** *%*
0-5	**63.4**	**53.8**
5-10	**16.4**	**18.3**
10-15	**6.2**	**8.5**
15-20	**5.5**	**6.4**
20-25	**3.0**	**5.4**
25-30	**2.0**	**2.7**
30-35	**1.5**	**1.2**
35-40	**0.8**	**0.6**
Over 40	**1.0**	**3.1**

Note
[1] Sample number refers to number of pedestrians.

On both streets, large delays at the kerb are experienced by the young and elderly and those who are accompanied (see appendix 4). On Bruntsfield Place average delays of 12.7 seconds and 16.9 seconds were recorded for the elderly and child age groups, compared to 10.5 seconds for the 18-65 age group. Similarly, results for Raeburn Place found that the elderly and children experienced mean delays of 14.8 seconds and 12.6 seconds, compared to 12.3 seconds for adults. Similarly, those pedestrians crossing accompanied experienced on average, larger delays than those crossing alone, 12.3 seconds compared to 10.3 seconds, on Bruntsfield Place, and 15.2 seconds compared to 12.5 seconds on Raeburn Place (see appendix 4).

Frequency distributions of pedestrian delay by age clearly indicate the differences in delay experienced by different age groups. Noticeably, 57.5% of adult pedestrians experienced delays of only 0-5 seconds, compared to 56.4% and 47.8% in the child and elderly age groups respectively. However, the proportions found experiencing long delays of over 35 seconds were larger for children and the elderly (figure 4.4). It would therefore seem that conditions experienced at informal crossing locations (i.e. not at pedestrian crossing facilities) do not favour pedestrian mobility especially for those in the under 18 age group and the over 65 age group who are not able to avoid long delays at the kerb.

Figure 4.4 Distribution of Pedestrian Delays by Age, Raeburn Place.



Further analysis of the Raeburn Place video data clearly indicates the extent to which the delay experienced by pedestrians is linked to other pedestrian behaviour measures. Table 4.11 illustrates the correlation coefficients between the other behavioural measures and delay. Delay is primarily affected by nearside traffic flow (r=0.3) and to a lesser extent by farside traffic flow (r=0.2412), with total flow having a larger impact (r=0.3952). Although not strong correlations, these results do indicate that as traffic flow levels increase so do delays encountered by pedestrians.

Table 4.11 Pedestrian Delay and Other Behavioural Measures, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	**Correlation Coefficient (r)** *515*
Nearside Traffic Flow	**0.3000**
Farside Traffic Flow	**0.2412**
Total Flow	**0.3952**
Nearside Traffic Speed (kmh)	**-0.1144**
Farside Traffic Speed (kmh)	**-0.1580**
Nearside Acceptance Gap	**-0.0577**
Farside Acceptance Gap	**-0.1674**
Nearside Crossing Angles	**0.1470**
Farside Crossing Angles	**0.1470**
Total Crossing Time	**0.9294**
Number of Parked Vehicles	**0.0257**

Note
[1] **Sample number refers to number of pedestrians.**

Crosstabulations of this data using the Chi-square test (tables 4.12a-c) indicate that when traffic flows are in the range of 0-2 vehicles (within 15 seconds before crossing action is started) 48% of observed pedestrians in the nearside carriageway and 55.6% of observed pedestrians in the farside carriageway had delays lasting up to 5 seconds. When traffic levels increase to 4-6 vehicles (within 15 seconds before crossing action is started) 50.7% in the nearside and 34.3% in the farside carriageways experience delays of over 20 seconds (tables 4.12a-b). There are larger delays from the effect of combined traffic flows (tables 4.12c).

Table 4.12a Pedestrian Delay and Traffic Flow, Nearside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Delay Level						
Pedestrian Delay (secs)	**Sample Number[1]**		**Traffic Flow 0-2 (vehicles per 15 secs)**	**Traffic Flow 2-4 (vehicles per 15 secs)**	**Traffic Flow 4-6 (vehicles per 15 secs)**	**Traffic Flow 6+ (vehicles per 15 secs)**
0-5	**277**	%	**48.7**	**29.6**	**18.4**	**3.2**
5-10	**94**	%	**24.5**	**34.0**	**31.9**	**9.6**
10-15	**44**	%	**25.0**	**36.4**	**22.7**	**15.9**
15-20	**33**	%	**9.1**	**12.1**	**57.6**	**21.2**
Over 20	**67**	%	**17.9**	**16.4**	**50.7**	**14.9**

Note
[1] Sample number refers to the number of pedestrians.

Table 4.12b Pedestrian Delay and Traffic Flow, Farside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Delay Level						
Pedestrian Delay (secs)	Sample Number[1]		Traffic Flow 0-2 (vehicles per 15 secs)	Traffic Flow 2-4 (vehicles per 15 secs)	Traffic Flow 4-6 (vehicles per 15 secs)	Traffic Flow 6+ (vehicles per 15 secs)
0-5	277	%	55.6	22.7	17.0	4.7
5-10	94	%	37.2	36.2	19.1	7.4
10-15	44	%	36.4	29.5	22.7	11.4
15-20	33	%	51.5	21.2	15.2	12.1
Over 20	67	%	29.9	19.4	34.3	16.4

Note
[1] Sample number refers to the number of pedestrians.

Table 4.12c Pedestrian Delay and Total Traffic Flow, Both Carriageways, Raeburn Place.

% of Pedestrians Crossing per Delay Level						
Pedestrian Delay (secs)	Sample Number[1]		Traffic Flow 0-2 (vehicles per 15 secs)	Traffic Flow 2-4 (vehicles per 15 secs)	Traffic Flow 4-6 (vehicles per 15 secs)	Traffic Flow 6+ (vehicles per 15 secs)
0-5	277	%	15.9	27.8	22.0	34.3
5-10	94	%	0.0	17.0	23.4	59.6
10-15	44	%	0.0	4.5	34.1	61.4
15-20	33	%	0.0	0.0	30.3	69.7
Over 20	67	%	0.0	4.5	16.4	79.1

Note
[1] Sample number refers to the number of pedestrians.

The correlation between speed and flow is not high (r=-0.1798 and r=-0.1951 in the nearside and farside carriageway) and reflects the low traffic speeds and low variation in speeds on central area urban streets. This is influenced by a number of factors including platooning, high volumes of traffic, and parking activity. Data presented earlier in this chapter indicated that throughout the day on Raeburn Place there is relatively little variation in traffic speeds. The behavioural data indicates that traffic speeds taken at the time of crossing were low (mean = 27 kmh and standard deviation = 10 kmh in the nearside carriageway, and mean = 26 kmh and standard deviation = 10 kmh in the farside carriageway). This is due to high traffic volumes at the time of crossing (mean = 4 vehicles per 15 seconds before crossing and standard deviation = 2 vehicles in the nearside carriageway, and mean = 3 vehicles per 15 seconds before crossing and standard deviation = 2 vehicles in the farside carriageway) and the platooning of traffic flow on these tenemental radial routes. In the context of this type of street, where traffic speed levels are relatively low, speeds do not appear to be a factor of importance in determining the level of the traffic barrier. On the contrary the correlation coefficient with speeds (r=-0.1104 in the nearside carriageway and r=-0.1580 in the farside carriageway) indicates that as traffic speed increases delays experienced by pedestrians decline. This is also well illustrated by crosstabulated data. For example a high proportion of pedestrians (42.2%) experiencing low delays (0-5 seconds), crossed when speeds of the oncoming vehicle were in excess of 30 kmh in the farside carriageway (table 4.13).

Table 4.13 Pedestrian Delay and Traffic Speed, Farside Carriageway, Raeburn Place.

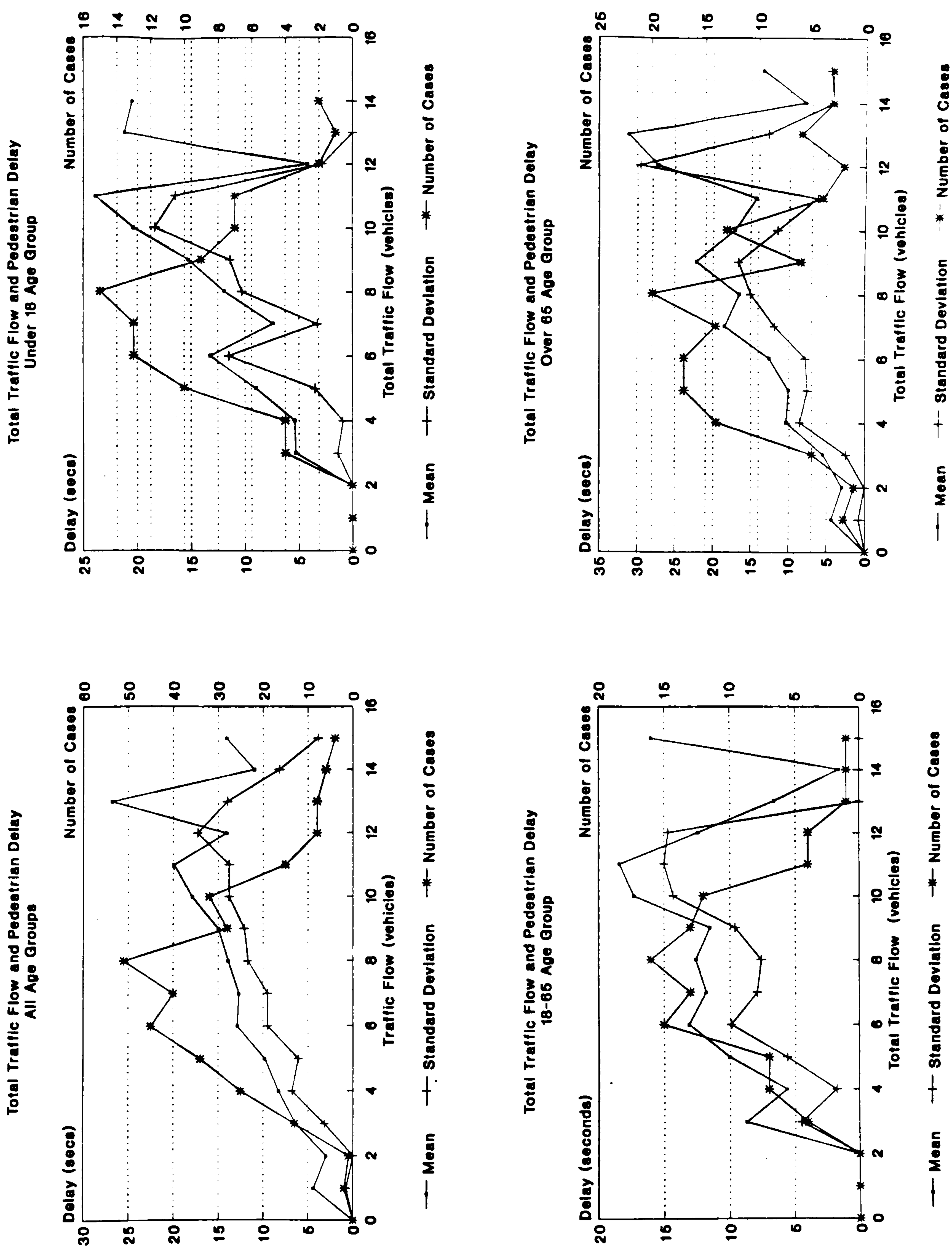
% of Pedestrians Crossing per Delay Level							
Pedestrian Delay (secs)	Sample Number[1]		Traffic Speed 0-15 (kmh)	Traffic Speed 15-20 (kmh)	Traffic Speed 20-25 (kmh)	Traffic Speed 25-30 (kmh)	Traffic Speed 30+ (kmh)
0-5	277	%	13.7	9.0	17.0	18.1	42.2
5-10	94	%	10.6	11.7	23.4	16.0	38.3
Over 10	144	%	13.9	18.1	22.9	17.4	27.8

Note
[1] **Sample number refers to the number of pedestrians**

Figure 4.5 plots the relationship between pedestrian delay and traffic flow by age group and indicates that the range of delays experienced is greater for the elderly and young, compared with the adult group. The extent of this variation, which is greater for lower levels of traffic flow, indicates that when crossing, the elderly and young are less able to judge traffic conditions and/or they need larger acceptance gaps because they cross more slowly. In the case of the elderly, this may also be associated with poorer health. The traffic clearly has a greater impact on children and elderly people at lower levels of flow.

This pattern is also reflected in the correlation coefficients of delay with traffic flow when disaggregated by age group (see appendix 4). The results show that the over 65 age group is more affected than the other age groups by the nearside traffic flow (r=0.4693). Heavier traffic flows in the nearside carriageway increase delays for this age group, while farside traffic flow has more effect on those aged under 18, compared to other age groups (r=0.4150). Traffic speeds of oncoming vehicles in the nearside carriageway have some effect, but to a lesser extent than traffic flow. They seem to have some effect on the

Figure 4.5 Pedestrian Delay and Traffic Flow, by Age, Raeburn Place.



delays of children (r= -0.17) and adults (r= -0.2036) but no significant effect for those in the over 65 age group (r= -0.0094). For the latter, delays seem to be more associated with low traffic speeds of oncoming vehicles in the farside carriageway (r= -0.2462).

The correlation coefficients for acceptance gaps indicated that although the relationship with pedestrian delay was not strong, that acceptance gap size increased as pedestrian delay declined (r=-0.0577 in the nearside carriageway and r=-0.1674 in the farside carriageway). For delays of only 0-5 seconds, a large proportion (65%) of pedestrians crossed into acceptance gaps of 15 seconds or more in the farside carriageway (table 4.14). Farside carriageway acceptance gaps appear to be more closely associated with the delays experienced by all age groups than acceptance gaps in the nearside carriageway.

Table 4.14 Pedestrian Delay and Acceptance Gaps, Farside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Delay Level								
Ped. Delay (secs)	**Sample Number[1]**		**0-10 (secs)**	**Accept. Gap 10-15 (secs)**	**Accept. Gap 15-20 (secs)**	**Accept. Gap 20-25 (secs)**	**Accept. Gap 25-30 (secs)**	**Accept. Gap 30+ (secs)**
0-5	**277**	%	**20.2**	**14.8**	**20.6**	**14.8**	**9.4**	**20.2**
5-10	**94**	%	**33.0**	**11.7**	**19.1**	**11.7**	**3.2**	**21.3**
Over 10	**144**	%	**32.6**	**16.0**	**18.8**	**11.1**	**9.7**	**11.8**

Note
[1] **Sample number refers to number of pedestrians.**

This evidence indicates that increases in delays are experienced by pedestrians when there are relatively high traffic flow levels, low speeds and small acceptance gaps. There is also evidence that difficulty in crossing the road resulting in increased delays also leads pedestrians to cross at steeper angles (r=0.1470), increasing angles being positively correlated with delay. This may indicate attempts by pedestrians to limit further increases in crossing time. Crosstabulations also emphasise that for each level of delay the proportion of pedestrians crossing at angles in the range of 80-90 degrees increases. For example 53.1% of pedestrians experiencing delays of 0-5 seconds crossed at an angle of 80-90 degrees, while 75.5% of pedestrians experiencing delays of 5-10 seconds crossed at 80-90 degrees (table 4.15).

Table 4.15 Pedestrian Delay and Crossing Angles, Both Carriageways, Raeburn Place.

% of Pedestrians Crossing per Delay Level								
Ped. Delay (secs)	Sample Number[1]		Angle 0°-40°	Angle 40°-50°	Angle 50°-60°	Angle 60°-70°	Angle 70°-80°	Angle 80°-90°
0-5	277	%	7.9	6.5	10.1	9.4	13.0	53.1
5-10	94	%	4.3	3.2	4.3	7.4	5.3	75.5
Over 10	144	%	4.2	2.8	4.2	11.8	11.8	65.3

Note
[1] **Sample number refers to number of pedestrians.**

As expected, total crossing time was found to be strongly dependent on delay (r=0.9294). Thus, for example, 97% of pedestrians with a delay of over 20 seconds were also found to have a total crossing time of over 25 seconds (table 4.16).

Table 4.16 Pedestrian Delay and Total Crossing Time, Raeburn Place.

% of Pedestrians Crossing per Delay Level							
Pedestrian Delay (secs)	Sample Number[1]		Crossing Time 0-10 (secs)	Crossing Time 10-15 (secs)	Crossing Time 15-20 (secs)	Crossing Time 20-25 (secs)	Crossing Time Over 25 (secs)
0-5	277	%	52.0	39.4	6.9	0.7	1.1
5-10	94	%	3.2	45.7	48.9	2.1	0.0
10-15	44	%	2.3	0.0	47.7	36.4	13.6
15-20	33	%	0.0	0.0	3.0	42.4	54.5
Over 20	67	%	0.0	1.5	0.0	1.5	97.0

Note
[1] Sample number refers to number of pedestrians.

Regression analysis indicates that total traffic flow, although accounting for only 15.6% of the variance in delay overall, is nonetheless a significant predictor of delay. The dominating influence of traffic flow, particularly on kerb delays for child and elderly pedestrians is evident from the results in table 4.17. The lower coefficients of determination for the adult age group indicate that the impact of traffic flow and, to a lesser extent, traffic speed, on kerb delays for this age group are much lower. The addition of traffic speed into the equation as a predictor does little to increase the value of R^2 and explain any additional variation in kerb delay (see appendix 4 for regression equations).

Disaggregations by sex or by walking situation revealed little in the way of significant differences in behaviour. Pedestrians observed walking alone on Raeburn Place appear to be more affected by nearside carriageway traffic flow conditions than those accompanied (alone r=0.3472 and accompanied r=0.2371), while pedestrians accompanied appear to be more affected by farside carriageway traffic flow (accompanied r=0.3342 and alone r=0.1647). Acceptance gaps in the farside carriageway, were found to have a greater

Table 4.17 Regression Analysis of Pedestrian Delay, Raeburn Place.

Overall - All Age Groups (Sample Number 515)

Independent Variable (step number)	Coefficient of Multiple Determination R^2
(1) Total Traffic Flow	0.156
(1) Traffic Speed Nearside Carriageway (2) Total Traffic Flow	0.157
(1) Traffic Speed Farside Carriageway (2) Traffic Speed Nearside Carriageway (3) Total Traffic Flow	0.159

Under 18 Years Old (Sample Number 156)

Independent Variable (step number)	Coefficient of Multiple Determination R^2
(1) Total Traffic Flow	0.195
(1) Traffic Speed Nearside Carriageway (2) Total Traffic Flow	0.202
(1) Traffic Speed Farside Carriageway (2) Traffic Speed Nearside Carriageway (3) Total Traffic Flow	0.205

18-65 Years Old (Sample Number 179)

Independent Variable (step number)	Coefficient of Multiple Determination R^2
(1) Total Traffic Flow	0.09
(2) Traffic Speed Nearside Carriageway (2) Total Traffic Flow	0.11
(1) Traffic Speed Farside Carriageway (2) Traffic Speed Nearside Carriageway (3) Total Traffic Flow	0.11

Over 65 Years Old (Sample Number 180)

Independent Variable (step number)	Coefficient of Multiple Determination R^2
(1) Total Traffic Flow	0.19
(1) Traffic Speed Nearside Carriageway (2) Total Traffic Flow	0.19
(1) Traffic Speed Farside Carriageway (2) Traffic Speed Nearside (3) Total Traffic Flow	0.21

Note See appendix 4 for regression equations.

influence on kerb delay, for pedestrians both alone and accompanied, (alone r=-0.1428 and accompanied r=-0.2134), than acceptance gaps in the nearside carriageway (alone r=-0.0381 and accompanied r=-0.1018) (see appendix 4).

No significant relationships between delay and the other behavioural measures were found for those pedestrians who were delayed in the carriageway. Traffic conditions at the time of crossing would appear to have little effect on the crossing behaviour of these pedestrians. At the different crossing locations where such delay was experienced, different factors seem to account for this delay. For those pedestrians observed crossing Raeburn Place whose delay position was in the gutter of the road, nearside traffic flow, and traffic speed in the farside carriageway were associated with delay (nearside traffic flow r=0.2065 and traffic speed farside carriageway r=-0.2135). For those pedestrians observed experiencing delay on the pavement, traffic speed in the farside carriageway was found to have a significant link with kerb delay (r=-0.1624).

Traffic flow conditions were found to particularly influence the delays associated with those using the offside of parked vehicles as a shelter from oncoming traffic (nearside traffic flow r=0.3154 and total traffic flow r=0.3599). Traffic speeds in both carriageways were also found to significantly influence delays at this location, but to a lesser extent (nearside r=-0.1625 and farside r=-0.1722) (see appendix 4). A larger number of variables are also significantly associated with this crossing location. This may indicate that those crossing from the offside of parked vehicles are particularly affected by the traffic barrier effect and could also be influenced by the density of parked vehicles. However, parking density was not analysed in this study. Further work is needed to evaluate the effect of parking density on pedestrian crossing behaviour.

4.3.5 Acceptance gap measures

Three gap measures were used in the study of Bruntsfield Place. These were defined earlier in chapter 3. Due to similar patterns in the distributions of the three gap measures, it was decided that for the purposes of the study of Raeburn Place, the acceptance gaps measure only (the time gap between vehicles in the traffic flow in which the pedestrian decides to cross) would be used.

On Bruntsfield Place, average acceptance gaps of 15.6 seconds and 14.2 seconds in the nearside and farside carriageways were recorded, while on Raeburn Place average acceptance gaps of 21.5 seconds in the nearside carriageway and 20.2 seconds in the farside carriageway were recorded. Both carriageways in both streets were found to exhibit a wide range of acceptance gaps from a maximum of 60 seconds and 51.4 seconds in the nearside and farside carriageways to a minimum of 0.9 and 2.4 seconds in the nearside and farside carriageways on Bruntsfield Place. On Raeburn Place the ranges of acceptance gaps experienced were found to be substantially larger from a maximum of 75 seconds and 93.4 seconds in the nearside carriageway to a minimum of 4 seconds and 3 seconds in nearside and farside carriageways (see appendix 4). The wider range of acceptance gaps on Raeburn Place may be linked to the higher levels of platooning associated with traffic light controlled junctions and the operation of Pelican crossings.

For both of the safety gap measures used in the Bruntsfield Place study (defined as (1) the time from when a pedestrian steps out into the road to when the next vehicle crosses the pedestrians path behind him/her; and (2) the amount of time each pedestrian had to spare over an approaching vehicle), as with the acceptance gaps, the average gaps are larger in the nearside carriageways: 11.45 seconds (standard deviation = 8.3 seconds; standard error of the mean = 0.34 seconds) compared to 8.65 seconds (standard deviation = 5.9 seconds; standard error of the mean = 0.25 seconds) in the farside for the first safety gap measure; while for the second measure the nearside average gap is 8.42 seconds (standard deviation = 8.3 seconds; standard error of the mean = 0.34 seconds) compared to 5.28 seconds in the farside carriageway (standard deviation = 5.4 seconds; standard error of the mean = 0.22 seconds).

Table 4.18 Distribution of Acceptance Gaps (seconds), Bruntsfield Place and Raeburn Place.

	Bruntsfield Place		Raeburn Place	
Acceptance Gap (secs) *Sample Number*[1]	**Nearside Carriageway** *596* *(%)*	**Farside Carriageway** *596* *(%)*	**Nearside Carriageway** *515* *(%)*	**Farside Carriageway** *515* *(%)*
0-5	**12.6**	**16.3**	**4.3**	**9.5**
5-10	**29.2**	**25.0**	**16.3**	**16.5**
10-15	**17.3**	**19.6**	**19.4**	**14.6**
15-20	**14.9**	**19.8**	**16.9**	**19.8**
20-25	**8.2**	**7.9**	**13.2**	**13.2**
25-30	**7.9**	**6.0**	**8.7**	**8.3**
30-35	**4.7**	**2.9**	**6.4**	**4.9**
35-40	**1.8**	**1.7**	**7.6**	**6.0**
40+	**3.4**	**0.8**	**7.2**	**7.2**

Note
[1] **Sample number refers to number of pedestrians.**

The effect of platooning is also evident in the distributions of acceptance gaps on Raeburn Place, when compared to those gaps on Bruntsfield Place. On Bruntsfield Place a large proportion of pedestrians have acceptance gaps of under 10 seconds; 41.8% nearside and 41.3% farside, yet the proportions of pedestrians who cross into gaps of 10-15 seconds and 15-20 seconds are larger on the farside carriageway than the nearside carriageway; 19.6% and 19.8%, compared to 17.3% and 14.9% (table 4.18). On Raeburn Place, however, a greater proportion of pedestrians are crossing into larger gaps. 49.5% of pedestrians crossing in the nearside carriageway were found to have acceptance gaps of 10-25 seconds, while in the farside carriageway 41.3% of pedestrians were found to have acceptance gaps of 15-30 seconds. The greater proportions of pedestrians crossing into larger acceptance gaps on Raeburn Place, in so far as it is due to platooning, indicates that traffic flow levels are relatively low at these times. It will also be influenced by the composition of the Raeburn Place sample however, with larger proportions in the under 18 and over 65 age groups.

Figure 4.6a Distribution of Acceptance Gaps by Age, Nearside Carriageway, Raeburn Place.

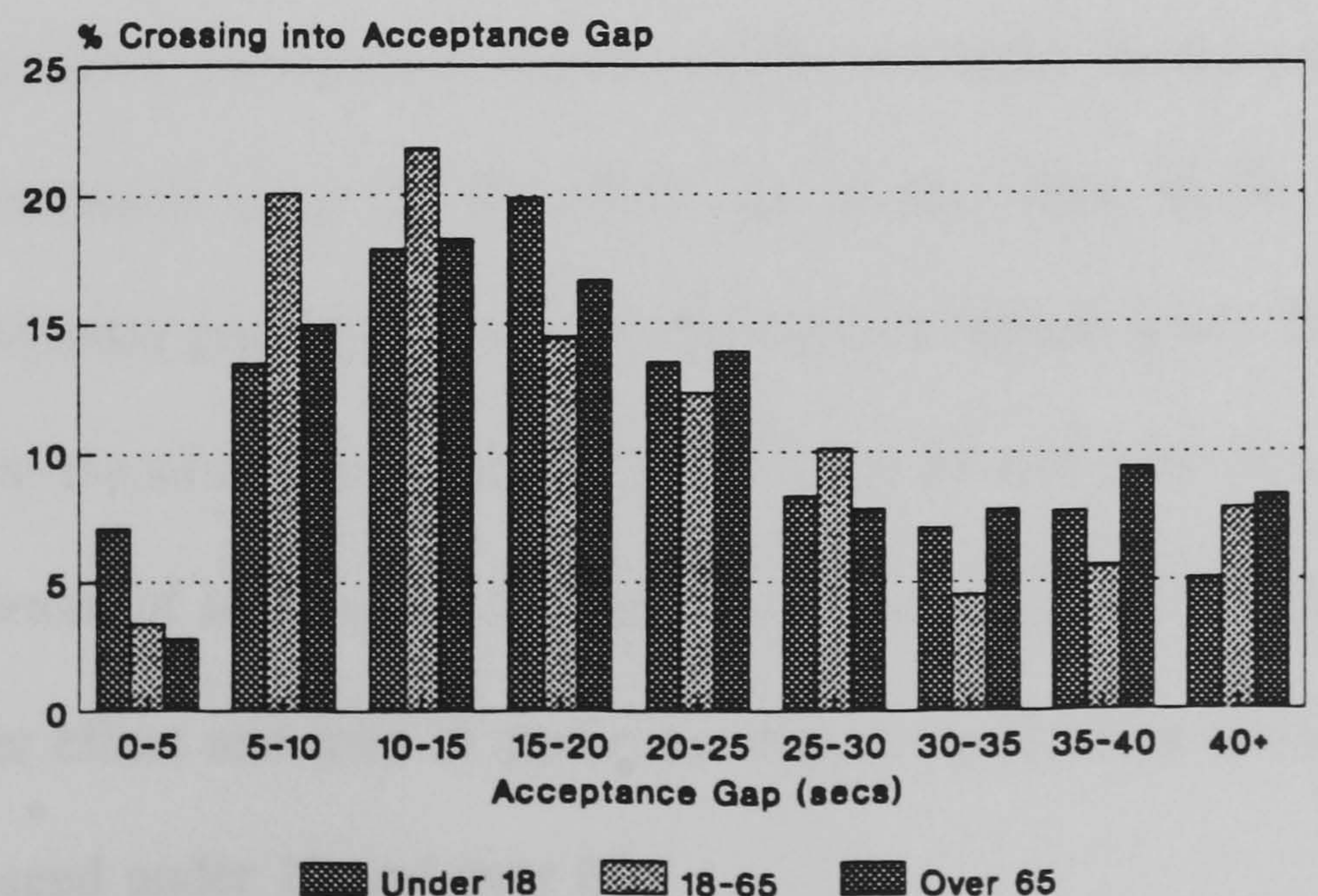
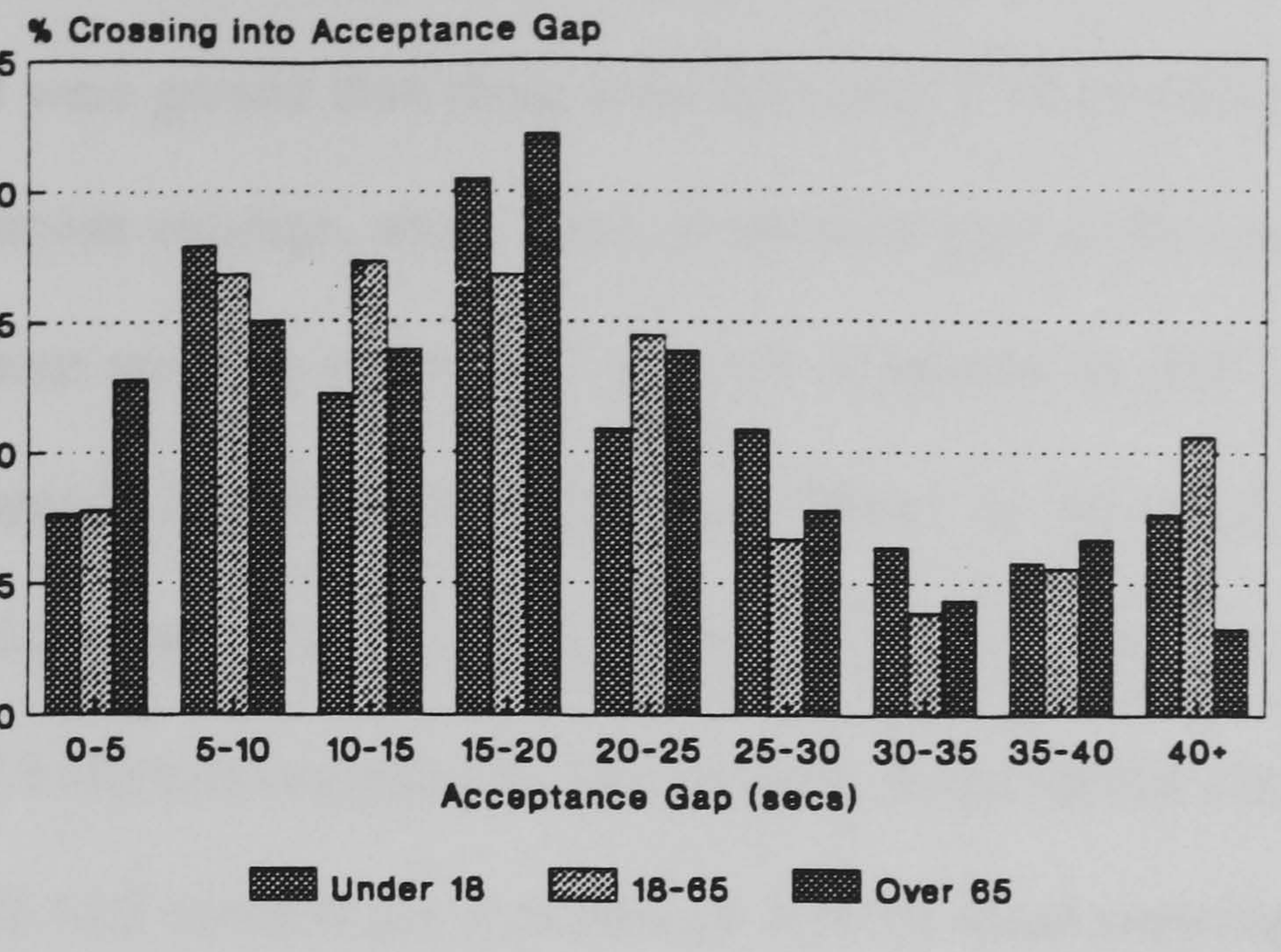


Figure 4.6b Distribution of Acceptance Gaps by Age, Farside Carriageway, Raeburn Place.



Comparison of the distribution of acceptance gaps indicate that large proportions of those aged over 65, and those aged under 18, cross into relatively large acceptance gaps of over 20 seconds, in comparison to those aged 18-65 (figure 4.6a-b). This pattern is also reflected in mean acceptance gaps (see appendix 4). On Raeburn Place mean acceptance gaps in the nearside carriageway are slightly greater for the under 18 and over 65 age groups at 21.3 seconds and 22.7 seconds compared to 20.4 seconds for those aged 18-65. On the farside carriageway this pattern is reversed with the 18-65 age group having greater mean acceptance gaps of 21 seconds compared to 20.4 seconds for those aged under 18 and 19 seconds for those aged over 65. On Bruntsfield Place average acceptance gaps in the nearside carriageway experienced by the under 18 and over 65 age groups are less than acceptance gaps for the 18-65 age group, while in the farside carriageway average acceptance gaps for all age groups are at a similar level. This may however be largely due to the small sample sizes for the under 18 and over 65 age groups. Increases in the proportion of large acceptance gaps, can produce corresponding reductions in the traffic barrier effect and may in particular improve pedestrian mobility levels for those pedestrians aged under 18 and over 65.

No clear difference was found to exist between acceptance gaps chosen by those crossing alone or accompanied. On Raeburn Place, mean acceptance gaps for those crossing the road accompanied were greater than those crossing alone: 23.5 seconds compared to 20.5 seconds in the nearside carriage, while mean acceptance gaps in the farside carriageway were larger for those crossing alone: 20.3 seconds compared to 19.8 seconds for those crossing accompanied. Similarly on Bruntsfield Place, in the nearside carriageway, acceptance gaps for those crossing accompanied are smaller than for those pedestrians crossing alone: 14.9 seconds compared to 15.8 seconds. In the farside carriageway average acceptance gaps of 14.2 seconds are experienced both by those crossing alone and those accompanied (see appendix 4).

Table 4.19 Acceptance Gaps and Other Behavioural Measures, Correlation Coefficients, Nearside and Farside Carriageways, Raeburn Place.

Behavioural Measure ***Sample Number*[1]**	**Correlation Coefficient Nearside (r)** ***515***	**Correlation Coefficient Farside (r)** ***515***
Pedestrian Delay	**-0.0577***	**-0.1674**
Nearside Traffic Flow	**-0.3385**	**0.0444***
Farside Traffic Flow	**0.0980**	**-0.4826**
Total Traffic Flow	**-0.1641**	**-0.3362**
Nearside Traffic Speed	**0.2245**	**0.1220**
Farside Traffic Speed	**0.0939**	**0.2708**
Crossing Angle Nearside	**-0.0670***	**-0.0241***
Crossing Angle Farside	**-0.0670***	**-0.0241***
Total Crossing Time	**-0.0006***	**-0.1533**
Number of Parked Vehicles	**-0.0519***	**-0.1058**

Note
[1] Sample number refers to number of pedestrians.
*** Not Significant.**

Further analysis of the behavioural data for Raeburn Place revealed that acceptance gaps in each carriageway are principally associated with traffic flow and, to a lesser extent, speed conditions existing at the time of crossing (table 4.19). For both carriageways, heavier traffic flows are associated with smaller acceptance gaps, while higher traffic speed levels are associated with larger acceptance gaps. Acceptance gaps in both carriageways are principally affected by traffic flow levels in their respective carriageways (nearside traffic flow r=-0.3385 and farside traffic flow r=-0.4826). Traffic speed would appear to be less significant (nearside traffic speed r=0.2245 and farside traffic speed r=0.2708). Crosstabulations of the impact of traffic speed and flow conditions at the time of crossing with acceptance gaps, in the nearside and farside carriageways, illustrate these relationships well. Pedestrians crossing into acceptance gaps of 0-10 seconds experience comparatively high traffic barrier effects. 36.8% of pedestrians crossing with acceptance gaps in the range of 0-10 seconds, encountered a traffic flow level of 4-6 vehicles. Conversely, a larger proportion of pedestrians crossed at lower traffic flow levels of 0-2 vehicles into acceptance gaps of over 20 seconds (table 4.20). Similarly, low traffic speeds are associated with smaller acceptance gaps. For traffic speeds of over 30 kmh, a higher proportion of pedestrians crossed into acceptance gaps of 25-30 seconds, 57.8%, compared to 26.4% who crossed into gaps of 0-10 seconds when associated traffic speed levels were 0-15 kmh in the nearside carriageway (table 4.21). Similar relationships between acceptance gaps and traffic flow and speed levels at the time of crossing appear in crosstabulations for the farside carriageway (table 4.22 and 4.23).

The relationship between farside acceptance gaps and total crossing time is also well illustrated by crosstabulated data (table 4.24). This indicates that as the size of the acceptance gap increases, total crossing time declines. For example, 23.9% of pedestrians with acceptance gaps of 0-10 seconds in length were also found to have a total crossing time of 15-20 seconds. Those pedestrians who crossed into gaps of 25-30 seconds consequently reduced their total crossing times to 10-15 seconds.

Table 4.20 Acceptance Gaps and Traffic Flow, Nearside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Acceptance Gap Level						
Acceptance Gap (secs)	**Sample Number[1]**		**Traffic Flow 0-2 (vehicles per 15 secs)**	**Traffic Flow 2-4 (vehicles per 15 secs)**	**Traffic Flow 4-6 (vehicles per 15 secs)**	**Traffic Flow 6+ (vehicles per 15 secs)**
0-10	**106**	%	**22.6**	**25.5**	**36.8**	**15.1**
10-15	**100**	%	**20.0**	**32.0**	**39.0**	**9.0**
15-20	**87**	%	**33.3**	**34.5**	**31.0**	**1.1**
20-25	**68**	%	**48.5**	**19.1**	**20.6**	**11.8**
25-30	**45**	%	**51.1**	**26.7**	**13.3**	**8.9**
Over 30	**109**	%	**50.5**	**28.4**	**17.4**	**3.7**

Note
[1] Sample number refers to number of pedestrians.

Table 4.21 Acceptance Gaps and Traffic Speed, Nearside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Acceptance Gap Level							
Accept. Gap (secs)	Sample Number[1]		Traffic Speed 0-15 (kmh)	Traffic Speed 15-20 (kmh)	Traffic Speed 20-25 (kmh)	Traffic Speed 25-30 (kmh)	Traffic Speed 30+ (kmh)
0-10	106	%	26.4	14.2	14.2	12.3	33.0
10-15	100	%	8.0	13.0	14.0	30.0	35.0
15-20	87	%	3.4	13.8	25.3	20.7	36.8
20-25	68	%	4.4	13.2	13.2	16.2	52.9
25-30	45	%	6.7	0.0	15.6	20.0	57.8
Over 30	109	%	4.6	11.9	19.3	19.3	45.0

Note
[1] Sample number refers to number of pedestrians.

Table 4.22 Acceptance Gaps and Traffic Flow, Farside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Acceptance Gap Level						
Acceptance Gap (secs)	Sample Number[1]		Traffic Flow 0-2 (vehicles per 15 secs)	Traffic Flow 2-4 (vehicles per 15 secs)	Traffic Flow 4-6 (vehicles per 15 secs)	Traffic Flow 6+ (vehicles per 15 secs)
0-10	134	%	23.9	25.4	28.4	22.4
10-15	75	%	41.3	32.0	22.7	4.0
15-20	102	%	42.2	33.3	22.5	2.0
20-25	68	%	50.0	27.9	20.6	1.5
25-30	43	%	69.8	20.9	7.0	2.3
Over 30	93	%	77.4	10.8	8.6	3.2

Note
[1] Sample number refers to number of pedestrians.

Table 4.23 Acceptance Gaps and Traffic Speed, Farside Carriageway, Raeburn Place

% of Pedestrians Crossing per Acceptance Gap Level							
Accept. Gap (secs)	Sample Number[1]		Traffic Speed 0-15 (kmh)	Traffic Speed 15-20 (kmh)	Traffic Speed 20-25 (kmh)	Traffic Speed 25-30 (kmh)	Traffic Speed 30+ (kmh)
0-10	134	%	31.3	14.2	11.2	17.9	25.4
10-15	75	%	12.0	16.0	26.7	12.0	33.3
15-20	102	%	4.9	8.8	29.4	21.6	35.3
20-25	68	%	7.4	1.5	17.6	19.1	54.4
25-30	43	%	2.3	9.3	25.6	7.0	55.8
Over 30	93	%	6.5	18.3	15.1	20.4	39.8

Note
[1] Sample number refers to number of pedestrians.

Table 4.24 Acceptance Gaps and Total Crossing Times, Raeburn Place.

% of Pedestrians Crossing per Acceptance Gap Level							
Accept. Gap (secs)	Sample Number[1]		Crossing Time 0-10 (secs)	Crossing Time 10-15 (secs)	Crossing Time 15-20 (secs)	Crossing Time 20-25 (secs)	Crossing Time 25+ (secs)
0-10	134	%	23.1	24.6	23.9	6.7	21.6
10-15	75	%	29.3	29.3	8.0	8.0	25.3
15-20	102	%	26.5	35.3	11.8	6.9	19.6
20-25	68	%	36.8	26.5	14.7	13.2	8.8
25-30	43	%	23.3	37.2	14.0	4.7	20.9
Over 30	93	%	35.5	30.1	22.6	2.2	9.7

Note
[1] Sample number refers to numbers of pedestrians.

The impact of traffic flow and speed levels on acceptance gaps, in both carriageways, is reiterated by age group. In the nearside carriageway acceptance gaps for all age groups are clearly affected by nearside carriageway traffic flow conditions (under 18 r=-0.3360; 18-65 r=-0.3642; over 65 r=-0.3119). Nearside traffic speed appears to have less impact on those aged over 65 (r=0.1387) than on those pedestrians aged under 18 (r=0.2510) and 18-65 (r=0.3004). This may be linked to the lower levels of ability, associated with the elderly age group, in assessing traffic conditions, particularly traffic speed.

Acceptance gaps for all age groups in the farside carriageway are affected by traffic flow levels existing in this carriageway, especially for those pedestrians aged under 18 and over 65 (under 18 r=-0.5532; 18-65 r=-0.4206; over 65 r=-0.4915). Farside carriageway traffic speed again appears to have a lesser impact on the acceptance gaps of those aged under 18 (r=0.2778) and over 65 (r=0.2701), and even less impact on pedestrians aged 18-65 (r=0.1533). Farside carriageway acceptance gaps for those aged under 18 are also significantly associated with the number of parked vehicles present in the street (r=-0.1965) (see appendix 4).

The choice of acceptance gaps by pedestrians aged over 65 also appears to be affected by the number of parked vehicles present in Raeburn Place at the time of crossing (r=-0.1282). This result appears to suggest that a high volume of parked cars in the street section is associated with smaller acceptance gaps, but it could be entirely due to the existence of high traffic flow during periods associated with high levels of parking activity. Regression analysis indicated that parking made no significant independent contribution to the selection of acceptance gaps. This, as with speed, may be linked to poor judgement of traffic conditions at the time of crossing. As such, it would appear that parked cars may be a hindrance to the elderly when they cross the road (see appendix 4).

Correlations for those crossing alone and accompanied, and correlations for male and female pedestrians revealed little in the way of significant differences in behaviour. Farside carriageway acceptance gaps, both for those crossing alone and accompanied, are clearly more affected by total traffic flow conditions than nearside acceptance gaps (alone, farside carriageway r=-0.3042, compared to nearside carriageway r=-0.1918; and accompanied farside carriageway r=-0.4019, compared to nearside carriageway r=-0.1308) (see appendix 4).

Regression analysis also indicated the relative importance of traffic flow and speed conditions in each carriageway, in terms of the acceptance gaps taken by pedestrians on Raeburn Place (table 4.25). As with pedestrian delays, the regression analysis confirmed that traffic flow was a more dominant factor than speed in determining acceptance gaps.

Initial analysis for all age groups indicated that nearside carriageway traffic flow was found to account for 11% of the variation in acceptance gaps. The introduction of nearside traffic speed, into the regression analysis, produced a significant increase in prediction, explaining 14% of the variation. Similarly for the farside carriageway, regression analysis indicated that flow was a significant explanatory variable of farside carriageway acceptance gaps (r^2=0.23). However, the introduction of farside carriageway speed only produced an increase of 1% in the explanation of the variation (R^2=0.24). The results for both carriageways do not explain the very large variation in acceptance gaps. This is principally due to the differences in individual approaches to crossing the road and the circumstances existing at the time of crossing.

Results indicate that traffic flow and speed effects, in the nearside carriageway are higher for those aged 18-65 (R^2=0.16) than for the elderly (R^2=0.11). This however, is not the case for the farside carriageway, where flow and speed effects are at a higher level for the over 65 age group (R^2=0.24). Regression analysis of acceptance gaps in the nearside carriageway, for the under 18 age group, indicate little difference from that of the overall picture (r^2=0.11 traffic flow), possibly due to the high levels of adult accompaniment associated with this age group.

Results for the elderly suggest very little, if any, improvement in prediction with the introduction of traffic speed into the equation, for both carriageways, at the 95% level of confidence. These results suggest that the elderly may not be as aware of traffic speed in their crossing behaviour, and it is not an explanatory variable in the choice of acceptance gaps. Indeed, the contribution of speed is not significant. This could be related to poor levels of perception and vision, associated with this age group, and this may contribute to a lower level of awareness of factors impinging on the pedestrian environment.

Table 4.25 Regression Analysis, Acceptance Gaps, Raeburn Place.

All Age Groups (Sample Number 515)

Independent Variable (step number)	Nearside Carriageway Coefficient of Multiple Determination R^2	Farside Carriageway Coefficient of Multiple Determination R^2
(1) Traffic Flow	0.11	0.23
(1) Traffic Speed and (2) Traffic Flow	0.14	0.24

Under 18 Years Old (Sample Number 156)

Independent Variable (step number)	Nearside Carriageway Coefficient of Multiple Determination R^2	Farside Carriageway Coefficient of Multiple Determination R^2
(1) Traffic Flow	0.11	0.30
(1) Traffic Speed and (2) Traffic Flow	0.15	0.31

18-65 Years Old (Sample Number 179)

Independent Variable (step number)	Nearside Carriageway Coefficient of Multiple Determination R^2	Farside Carriageway Coefficient of Multiple Determination R^2
(1) Traffic Flow	0.13	0.17
(1) Traffic Speed and (2) Traffic Flow	0.16	0.20

Over 65 Years Old (Sample Number 180)

Independent Variable (step number)	Nearside Carriageway Coefficient of Multiple Determination R^2	Farside Carriageway Coefficient of Multiple Determination R^2
(1) Traffic Flow	0.09	0.24
(1) Traffic Speed and (2) Traffic Flow	0.11	0.24

Note
See appendix 4 for regression equations.

For adults it is clear that speed makes an independent contribution in terms of the choice of acceptance gaps, accounting for increases of 3% in the explanation of the variation, in both carriageways. Similarly, for those pedestrians aged under 18, an increase of 4% in the explained variation is associated with the contribution of speed in the nearside carriageway and 1% in the farside carriageway.

4.3.6 Crossing angles

Crossing angles for both nearside and farside carriageways were recorded for both Bruntsfield Place and Raeburn Place. In both streets, pedestrians cross the carriageway kerb to kerb at constant angles. On radial routes crossing angles were found to be steep, on Bruntsfield Place a mean crossing angle for both carriageways of 70.8 degrees, and of 78.2 degrees on Raeburn Place were recorded (see appendix 4). In both streets a substantial proportion of crossing angles were in the range of 80-90 degrees (table 4.26). Disaggregations by age for Raeburn Place and Bruntsfield Place reveal that pedestrians aged under 18 and over 65 cross at steeper angles than those aged 18-65. For example, on Raeburn Place the average crossing angles for pedestrians aged under 18 and over 65 are 77.2 degrees and 80.4 degrees respectively, compared with 76.8 degrees for the 18-65 age group. This is reflected in the distribution of crossing angles associated with the under 18 and over 65 age groups (table 4.27) (see appendix 4 for more detail).

Table 4.26 Distribution of Crossing Angles, Bruntsfield Place and Raeburn Place.

Crossing Angle *Sample Number*[1]	Raeburn Place Both Carriageways *515* %	Bruntsfield Place Both Carriageways *596* %
0-40	6.2	13.4
40-50	4.9	6.8
50-60	7.4	10.1
60-70	9.7	12.3
70-80	11.3	13.2
80-90	60.6	44.3

Note
[1] Sample number refers to number of pedestrians.

Table 4.27 Distribution of Crossing Angles by Age, Raeburn Place.

Crossing Angle *Sample Number*[1]	Under 18 *156* (%)	18-65 *179* (%)	Over 65 *180* (%)
0-40	4.5	8.9	5.0
40-50	7.7	5.6	1.7
50-60	9.0	8.4	5.0
60-70	7.7	10.1	11.1
70-80	17.3	5.6	11.7
80-90	53.8	61.5	65.6

Note
[1] Sample number refers to number of pedestrians.

Crossing angles are also affected by walking situation. Accompanied pedestrians cross at steeper angles than those crossing alone. For example, on Raeburn Place, those pedestrians who were accompanied had an average crossing angle of 80.5 degrees compared to 76.9 degrees for those crossing alone. A similar pattern is also apparent on Bruntsfield Place (see appendix 4). This indicates that the barrier effect is experienced to a greater extent by those pedestrians crossing accompanied; that is pedestrians who are less able to adopt flexible crossing strategies to cope with the traffic conditions.

Correlation coefficients based on the Raeburn Place video data indicate that crossing angles are associated with nearside traffic flow (r=0.1447); total traffic flow (r=0.1167); and farside traffic speed levels (r=-0.1321) (table 4.28). All other correlations were found to be insignificant. These results indicate that as traffic flow levels (nearside) increase and farside carriageway traffic speeds decrease, pedestrians' crossing angles become steeper in an attempt to reduce exposure time in the carriageway.

Table 4.28 Crossing Angle and Other Behavioural Measures, Both Carriageways, Raeburn Place.

Behavioural Measure *Sample Number*[1]	**Correlation Coefficient (r)** *515*
Pedestrian Delay	**0.1470**
Nearside Traffic Flow	**0.1447**
Farside Traffic Flow	**0.0193***
Total Flow	**0.1167**
Nearside Traffic Speed	**-0.0329***
Farside Traffic Speed	**-0.1321**
Acceptance Gap Nearside	**-0.0670***
Acceptance Gap Farside	**-0.0241***
Total Crossing Time	**0.0275***
Number of Parked Vehicles	**0.0660***

Note
[1] **Sample number refers to number of pedestrians.**
*** Not significant**

In conditions where the traffic barrier effect is lower, shallower crossing angles are taken. 42.1% of pedestrians crossing at angles in the range of 0-50 degrees did so when there were low traffic flow levels of 0-2 vehicles in the nearside carriageway in the 15 seconds before crossing Raeburn Place. Higher traffic levels of 4-6 vehicles resulted in 31.7% of pedestrians crossing at an angle of 80-90 degrees (table 4.29). For aggregate traffic flow (both carriageways) a similar pattern emerges (table 4.30). Similarly, lower speed levels were found to result in relatively steeper crossing angles. For example, when speeds were 0-15 kmh, 69.1% of pedestrians crossed at angles of 80-90 degrees, while when traffic speeds were 25-30 kmh, 31.1% of pedestrians crossed at angles of 0-70 degrees (table 4.31).

Table 4.29 Crossing Angle and Traffic Flow, Nearside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Crossing Angle Interval						
Crossing Angle (degrees)	**Sample Number[1]**		**Traffic Flow 0-2 (vehicles per 15 secs)**	**Traffic Flow 2-4 (vehicles per 15 secs)**	**Traffic Flow 4-6 (vehicles per 15 secs)**	**Traffic Flow 6+ (vehicles per 15 secs)**
0-50	57	%	42.1	36.8	17.5	3.5
50-70	88	%	36.4	29.5	27.3	6.8
70-80	58	%	43.1	22.4	19.0	15.5
80-90	312	%	33.0	27.2	31.7	8.0

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.30 Crossing Angle and Total Traffic Flow, Raeburn Place.

% of Pedestrians Crossing per Crossing Angle Interval						
Crossing Angle (degrees)	Sample Number[1]		Traffic Flow 0-2 (vehicles per 15 secs)	Traffic Flow 2-4 (vehicles per 15 secs)	Traffic Flow 4-6 (vehicles per 15 secs)	Traffic Flow 6+ (vehicles per 15 secs)
0-50	57	%	12.3	29.8	15.8	42.1
50-70	88	%	9.1	18.2	19.3	53.4
70-80	58	%	13.8	25.9	13.8	46.6
80-90	312	%	6.7	16.0	27.2	50.0

Note
[1] Sample number refers to number of pedestrians.

Table 4.31 Crossing Angle and Traffic Speed, Farside Carriageway, Raeburn Place.

% of Pedestrians Crossing per Crossing Angle Interval							
Crossing Angle (degrees)	Sample Number[1]		Traffic Speed 0-15 (kmh)	Traffic Speed 15-20 (kmh)	Traffic Speed 20-25 (kmh)	Traffic Speed 25-30 (kmh)	Traffic Speed 30+ (kmh)
0-50	57	%	2.9	11.3	7.8	10.0	16.1
50-70	88	%	14.7	14.5	22.5	21.1	14.0
70-80	58	%	13.2	19.4	5.9	8.9	11.9
80-90	312	%	69.1	54.8	63.7	60.0	58.0

Note
[1] Sample number refers to number of pedestrians.

Relationships between crossing angle and other behavioural measures did not vary significantly by age group (see appendix 4). In the case of those pedestrians aged under 18, the relationship between nearside traffic flow and crossing angles was found to be the only significant relationship (r=0.1668). For those pedestrians observed crossing Raeburn Place aged 18-65, significant relationships were found to exist between crossing angle and nearside carriageway traffic flow (r=0.2100); total traffic flow (r=0.2302); and farside traffic speed (r=-0.2172).

Crossing angles taken by pedestrians aged over 65 were affected by the number of parked vehicles in the street at the time of crossing (r=0.1741) and kerb delay (r=0.1727). The number of parked vehicles limits the choice of crossing location and destination points on the other side of the carriageway. This is compounded by the lower levels of mobility associated with the elderly age group in the selection of only "safe" angles. The longer kerb delays associated with this age group taking steeper crossing angles suggests a link with higher traffic volumes but in fact changing traffic flow levels appear to have little impact on the crossing angles of elderly pedestrians. This is clearly related to the fact that crossing angles are generally high for this group: 65.6% of those aged over 65 had crossing angles of 80-90 degrees when crossing Raeburn Place. For all traffic flow levels, conditions are too bad throughout the day for this age group to be able to adopt more flexible crossing strategies. This group would appear to be particularly susceptible to traffic barrier effects.

No significant differences were found in terms of the differential effects on the relationships between crossing angles and the other measures of behaviour, when disaggregated by walking situation and sex (see appendix 4).

4.3.7 Mode of crossing

On both case study streets most pedestrians were found to walk across both carriageways: 85.7% and 78.2% were found to walk across nearside and farside carriageways on Bruntsfield Place, and on Raeburn Place 92.8% and 89.5% walked across nearside and farside carriageways respectively (table 4.32). A larger proportion were found to run across both carriageways on Bruntsfield Place, 18% compared to 8.8% on Raeburn Place. Differences in the age structure of the samples account for part of this variation, but it may also indicate the existence of greater or more complex barrier effects on Bruntsfield Place, partially resulting from the greater road width. No micro-level measures of traffic flow and speed were taken at the time of crossing in the Bruntsfield Place video survey which could allow more detailed comparative analysis.

Table 4.32 Mode of Crossing, Bruntsfield Place and Raeburn Place.

	Bruntsfield Place		Raeburn Place	
Mode of Crossing *Sample Number*[1]	**Nearside Carriageway** *596* *%*	**Farside Carriageway** *596* *%*	**Nearside Carriageway** *515* *%*	**Farside Carriageway** *515* *%*
Walk	**85.7**	**78.2**	**92.8**	**89.5**
Run	**14.3**	**21.8**	**7.2**	**10.5**

Note
[1] **Sample number refers to number of pedestrians.**

Age was found to have a significant relationship with mode of crossing for both carriageways. Pedestrians aged under 18 have a greater tendency to run across each carriageway; 12.2% nearside and 19.9% farside (table 4.33a-b). This may be due to the high rates of accompaniment associated with this age group, (younger pedestrians may have to run across the road to keep up with their accompanying adult) or may be linked to the fact that children are less able to judge traffic conditions when crossing.

Table 4.33a Mode of Crossing and Age, Nearside Carriageway, Raeburn Place.

Age	Sample Number[1]		Walk	Run
Under 18	156	%	87.8	12.2
18-65	179	%	91.1	8.9
Over 65	180	%	98.9	1.1

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.33b Mode of Crossing and Age, Farside Carriageway. Raeburn Place.

Age	Sample Number[1]		Walk	Run
Under 18	156	%	80.1	19.9
18-65	179	%	89.9	10.1
Over 65	180	%	97.2	2.8

Note
[1] **Sample number refers to number of pedestrians.**

No significant relationship was found to exist between sex or walking situation of the pedestrian and mode of crossing for either carriageway.

Chi-square tests revealed no significant relationships between modes of crossing and acceptance gaps, traffic speeds or traffic flow, apart from one between nearside crossing mode and nearside traffic flow. Walking across the nearside carriageway is associated with higher traffic flow levels, while running is associated with lower levels of traffic flow and relatively higher speeds. 64.9% of those who did run across, did so when traffic flows were in the range of 0-2 vehicles (table 4.34). Related to these flow conditions, pedestrians, experiencing little or no delay, have a greater tendency to run across the carriageway.

A relatively high proportion of pedestrians observed walking across Raeburn Place (39.3%) experienced delay in the shelter of the offside of parked vehicles (table 4.35).

Table 4.34 Mode of Crossing and Traffic Flow Levels, Nearside Carriageway, Raeburn Place.

Mode of Crossing	Sample Number[1]		Traffic Flow 0-2 (vehicles per 15 secs)	Traffic Flow 2-4 (vehicles per 15 secs)	Traffic Flow 4-6 (vehicles per 15 secs)	Traffic Flow 6+ (vehicles per 15 secs)
Walk	478	%	45.6	25.9	20.3	8.2
Run	37	%	64.9	16.2	16.2	2.7

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.35 Mode of Crossing and Delay Position, Raeburn Place.

Delay Position *Sample Number[1]*	Walk *433* *%*	Run *36* *%*
Gutter	19.4	13.9
Shelter Offside of Vehicle	39.3	19.4
No Delay	41.2	66.7

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.36 Mode of Crossing and Safety Gaps, Both Carriageways, Bruntsfield Place.

	Nearside Carriageway		Farside Carriageway	
Safety Gap (secs)	**Walk**	**Run**	**Walk**	**Run**
Sample Number[1]	*511* %	*85* %	*466* %	*130* %
0-5	**17.8**	**35.7**	**18.0**	**29.5**
5-10	**41.6**	**32.1**	**40.0**	**39.5**
10-15	**18.4**	**8.3**	**19.0**	**10.9**
15-20	**9.5**	**8.3**	**10.4**	**5.4**
20-40	**11.1**	**15.5**	**11.0**	**14.0**
Over 40	**1.6**	**0.0**	**1.5**	**0.8**

Note
[1] **Sample number refers to number of pedestrians.**

Running across the carriageway is clearly linked to the choice of smaller safety gaps, despite the lack of any significant relationship between acceptance gaps and mode of crossing. On Bruntsfield Place, 35.7% who run across the nearside carriageway, have a safety gap of 0-5 seconds, compared to 17.8% who walk. A similar pattern is also recorded for the farside. 18% who walk have a safety gap of 5-10 seconds compared with 29.5% who run (table 4.36). Earlier findings indicated that running across the carriageway is associated with heavier traffic flow conditions, and smaller gaps in the traffic stream in which to cross.

4.3.8 Delay in the centre

Overall average delays recorded in the centre of Bruntsfield Place were slightly larger than those recorded in the centre of Raeburn Place: 6.63 seconds compared to 4.9 seconds (see appendix 4). Delay in the centre is experienced by very few pedestrians on either Bruntsfield Place or Raeburn Place. 85.4% on Bruntsfield Place and 92.4% on Raeburn Place experienced no such delay. Data would appear to suggest that many pedestrians are particularly skilful in choosing the appropriate combinations of acceptance gaps in both carriageways as determined by traffic flow and speed conditions existing at the time of crossing.

4.3.9 Crossing from behind parked vehicles

On both Bruntsfield Place and Raeburn Place a substantial proportion of crossings were undertaken from behind parked vehicles. On Bruntsfield Place, 62.1% of all crossings were from behind parked cars with a slightly lower figure of 60.6% on Raeburn Place (table 4.37). No significant differences were found to exist between age groups in terms of whether they crossed from behind a parked vehicle or not.

Table 4.37 Crossing from Behind Parked Vehicles, Bruntsfield Place and Raeburn Place.

Crossing Behind Parked Vehicle *Sample Number*[1]	Bruntsfield Place *596* *%*	Raeburn Place *515* *%*
Yes	62.1	60.6
No	37.9	39.4

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.38 Crossing from Behind Parked Vehicles and Crossing Angles, Both Carriageways, Bruntsfield Place and Raeburn Place.

	% of Pedestrians Crossing from Behind Parked Vehicles		% of Pedestrians Not Crossing from Behind Parked Vehicles	
Crossing Angle (degrees)	**Bruntsfield Place**	**Raeburn Place**	**Bruntsfield Place**	**Raeburn Place**
Sample Number[1]	*370* %	*312* %	*226* %	*203* %
0-60	**26.1**	**15.0**	**36.0**	**23.6**
60-70	**12.0**	**9.9**	**13.2**	**9.4**
70-80	**14.9**	**11.2**	**11.0**	**11.3**
80-90	**47.0**	**63.8**	**39.9**	**55.7**

Note
[1] **Sample number refers to number of pedestrians.**

Walking situation and mode of crossing for both carriageways were not found to be influenced by whether crossings were undertaken from behind parked vehicles or not. Crossing angles were significantly affected however, with the proportion of pedestrians crossing at steep angles increasing when crossing from behind a parked vehicle. The greater proportion of pedestrians crossing at steeper angles from behind parked vehicles, suggests that they are trying to mediate the barrier effect (table 4.38), by crossing from behind parked vehicles. This is also associated with heavy traffic flows (see p.189-190). Bruntsfield Place crossing angles were much shallower than those on Raeburn Place, whether or not pedestrians crossed from behind parked vehicles. For example, 26.1% of pedestrians who crossed from behind parked vehicles had crossing angles of up to 60 degrees in the nearside carriageway, compared to 15% on Raeburn Place. These results may reflect either the age distributions in each sample, with more pedestrians aged 18-65 in the Bruntsfield Place sample who tend to cross at shallower angles than in other age groups (see section 4.3.6), or merely differences in the level of parking activity occurring on both streets. Parking levels, however, were only recorded in the Raeburn Place study.

Further analysis of the Raeburn Place data has indicated that age effects, on crossing angles for those pedestrians crossing from behind parked vehicles, are significant (table 4.39a-b). Pedestrians under 18 in particular, appear to cross at slightly shallower angles from behind parked vehicles in comparison with those in the same age group who do not cross from behind parked vehicles. A similar pattern for the elderly is also revealed for crossing angles up to 60 degrees.

Table 4.39a Crossing from Behind Parked Vehicles and Age, Raeburn Place.

% of Pedestrians Crossing Behind Parked Vehicles by Age Group					
Crossing Angle (degrees)	Sample Number[1]		Under 18	18-65	Over 65
0-60	47	%	36.2	38.3	25.5
60-70	31	%	29.0	38.7	32.3
70-80	35	%	48.6	17.1	34.3
80-90	199	%	23.6	34.7	41.7

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.39b Not Crossing from Behind Parked Vehicles and Age, Raeburn Place.

% of Pedestrians Not Crossing Behind Parked Vehicles by Age Group					
Crossing Angle (degrees)	Sample Number[1]		Under 18	18-65	Over 65
0-60	48	%	33.3	47.9	18.8
60-70	19	%	15.8	31.6	52.6
70-80	23	%	43.5	17.4	39.1
80-90	113	%	32.7	36.3	31.0

Note
[1] **Sample number refers to number of pedestrians.**

Further analysis indicates that pedestrians crossing from behind parked vehicles experience reductions in the traffic barrier effect. High proportions of crossings undertaken from behind parked vehicles are associated with heavy traffic flow levels, low speed levels and shorter acceptance gaps in the nearside carriageway. Conversely, a higher proportion of crossings are not undertaken from behind parked vehicles when the traffic barrier effect is at a lower level: low traffic flow levels, relatively higher speed levels, and larger acceptance gaps. This may reflect lower levels of parking activity at lower flow times. Analysis has however indicated that the relationship between nearside traffic flow and the parking activity level is very low (r=0.0916). However, due to the data collection method, based on a structured stratified sample by age group, the characteristics of crossings undertaken from behind parked vehicles by time of day in relation to flow could not be fully explored. Further analysis would need to be undertaken by time of day to explore the relationship between the proportions crossing from behind parked vehicles and parking activity level.

In the context of central area tenemental-radial routes, where traffic speeds are lower, traffic flow has been identified as a dominant factor in determining the extent of the traffic barrier. Traffic flow on the nearside carriageway had an impact on crossings undertaken from behind parked vehicles. At flow levels of over 4 vehicles in the 15 seconds before crossing (see chapter 3 regarding this definition of flow), 51.3% crossed from behind parked vehicles compared to 48.7% for other crossings (table 4.40). Lower vehicle speeds, in the nearside carriageway only, are associated with a high proportion of crossings undertaken from behind parked vehicles: 84% of those crossing from behind a parked vehicle crossed when speeds of the oncoming vehicles were up to 15 kmh (table 4.41). This higher proportion crossing from behind parked vehicles with lower speeds and higher levels of traffic flow suggests that the barrier effect is reduced by parked vehicles.

Table 4.40 Crossing from Behind a Parked Vehicle and Traffic Flow, Nearside Carriageway, Raeburn Place.

Traffic Flow (vehicles 15 secs before crossing)	Sample Number[1]		Crossing Behind Parked Vehicle	Not Crossing Behind Parked Vehicle
0-2	184	%	44.7	55.3
2-4	145	%	55.3	44.7
Over 4	186	%	51.3	48.7

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.41 Crossing from Behind Parked Vehicles and Speed of Oncoming Vehicle, Nearside Carriageway, Raeburn Place.

Traffic Speed (kmh)	Sample Number[1]		Crossing from Behind Parked Vehicle	Not Crossing from Behind Parked Vehicle
0-15	50	%	84.0	16.0
15-20	62	%	51.6	48.4
20-25	88	%	62.5	37.5
25-30	102	%	57.8	42.2
Over 30	213	%	58.2	41.8

Note
[1] **Sample number refers to number of pedestrians.**

Choice of acceptance gaps in both carriageways is consistent with whether crossings are undertaken from behind parked vehicles or not. Although no controls for flow level were undertaken, substantially higher proportions of pedestrians crossing from behind parked vehicles appear to have acceptance gaps which are concentrated at 0-10 seconds or at over 30 seconds where platooning occurs at higher flow levels (table 4.42a-d). This suggests that crossing from behind parked vehicles enables larger proportions of pedestrians to cross into smaller acceptance gaps at relatively higher levels of traffic flow. This is consistent with a reduction in the traffic barrier effect for those crossing from behind parked vehicles. Further analysis however needs to be undertaken where controls for flow levels can be introduced.

Table 4.42a Crossing from Behind Parked Vehicles and Acceptance Gaps, Nearside Carriageway, Raeburn Place.

Acceptance Gap (secs)	Sample Number[1]		Yes	No
0-10	106	%	68.9	31.1
10-15	100	%	58.0	42.0
15-20	87	%	51.7	48.3
20-25	68	%	48.5	51.5
25-30	45	%	44.4	55.6
Over 30	109	%	76.1	23.9

Note
[1] Sample number refers to number of pedestrians.

Table 4.42b Crossing from Behind Parked Vehicles and Acceptance Gaps, Farside Carriageway, Raeburn Place.

Acceptance Gap (secs)	Sample Number[1]		Yes	No
0-10	134	%	54.5	45.5
10-15	75	%	66.7	33.3
15-20	102	%	59.8	40.2
20-25	68	%	66.2	33.8
25-30	43	%	62.8	37.2
Over 30	93	%	60.2	39.8

Note
[1] Sample Number refers to number of pedestrians.

Table 4.42c Crossing from Behind Parked Vehicles and Acceptance Gaps, Nearside Carriageway, Bruntsfield Place.

Acceptance Gaps (seconds)	Sample Number[1]		Yes	No
0-10	249	%	62.7	37.3
10-15	103	%	51.5	48.5
15-20	89	%	58.4	41.6
20-25	49	%	65.3	34.7
25-30	47	%	72.3	27.7
Over 30	59	%	69.5	30.5

Note
[1] Sample number refers to number of pedestrians.

Table 4.42d Crossing from Behind Parked Vehicles and Acceptance Gaps, Farside Carriageway, Bruntsfield Place.

Acceptance Gaps (seconds)	Sample Number[1]		Yes	No
0-10	246	%	53.7	46.3
10-15	117	%	58.1	41.9
15-20	118	%	75.4	24.6
20-25	47	%	72.3	27.7
25-30	36	%	66.7	33.3
Over 30	32	%	65.6	34.3

Note
[1] Sample number refers to number of pedestrians.

Evidence from the video study, reported later in this chapter, also suggests that the offside of parked cars were used as a shield from the oncoming traffic flow, which may enable pedestrians to select more appropriate gaps in the traffic. From analysis of the Bruntsfield Place data, crossing from behind a parked car does not appear to make any difference to the size of the safety gaps experienced.

A large number of crossings from behind parked vehicles are also linked to the numbers of parked vehicles in the street. Table 4.43 indicates that high volumes of parked vehicles, in association with heavy traffic flows and lower traffic speeds, are associated with high proportions of crossings undertaken from behind parked vehicles. Results from Bruntsfield Place reveal a significant relationship between crossing from behind a parked vehicle and time of day. This would appear to be linked directly with shop opening times and associated "stop-off trade". As can be seen in table 4.44, 65.4% of crossings made between 0800-0915, before shop opening times in Bruntsfield Place, were not made from behind a parked vehicle, compared to 79.3% of crossings made behind a parked vehicle between 1130-1330. It is not clear, however, how parking activity levels influence this interpretation of the use of parked vehicles in the crossing task. Further analysis would need to be undertaken to control for parking activity levels by time of day.

Table 4.43 Crossing from Behind Parked Vehicles and Parking Activity, Raeburn Place.

Number of Parked Vehicles	Sample Number[1]		Crossing Behind Parked Vehicle	Not Crossing Behind Parked Vehicle
0-5	24	%	33.3	66.7
5-10	293	%	56.3	43.7
10-15	198	%	70.2	29.8

Note
[1] **Sample number refers to number of pedestrians.**

Table 4.44 Crossing from Behind Parked Vehicles and Time Period, Bruntsfield Place.

Time Period	Sample Number[1]		Yes	No
0800-0915	26	%	34.6	65.4
0915-1130	81	%	59.3	40.7
1130-1330	145	%	79.3	20.7
1330-1500	80	%	45.0	55.0
1500-1730	160	%	62.5	37.5
1730-1845	59	%	62.7	37.3
1845-2000	42	%	54.8	45.2

Note
[1] **Sample number refers to number of pedestrians.**

Delays for those pedestrians observed crossing behind parked vehicles were found to be particularly affected by traffic flow conditions in both carriageways (nearside r=0.3073 and farside r=0.3044); speeds of oncoming vehicles in both carriageways (nearside r=-0.1268 and farside r=-0.1801); and acceptance gaps both carriageways (nearside r=-0.1302 and farside r=-0.2207) (see appendix 4). Table 4.45 indicates that a higher proportion of pedestrians crossing from behind parked vehicles experience delays of over 10 seconds, reflecting high traffic flow levels.

Table 4.45 Pedestrian Delays and Crossing from Behind a Parked Vehicle, Raeburn Place.

Pedestrian Delay (secs)	Sample Number[1]		Crossing from Behind Parked Vehicle	Not Crossing from Behind Parked Vehicle
0-5	277	%	58.1	41.9
5-10	94	%	56.4	43.6
10-15	44	%	68.2	31.8
15-20	33	%	78.8	21.2
Over 20	67	%	62.7	37.3

Note
[1] Sample number refers to number of pedestrians.

The actual position of delay experienced on Bruntsfield Place and Raeburn Place occurs at a number of locations, the most frequent location being at the offside of parked vehicles (table 4.46a-b). It was apparent from the video that delay positions, principally in the shelter of the offside of a parked vehicle are chosen for several reasons:

1) that moving off the kerb before crossing ensures slightly improved vision of the oncoming traffic, although this may not be so in the case of children who are often masked from the view of oncoming traffic by parked vehicles.

2) that by experiencing delays at locations other than on the kerb, pedestrians are more able to select appropriate gaps in the traffic stream. Data collected from the Raeburn Place study clearly suggests that this is the case. Position of delay experienced by the pedestrian was found to be significant with whether crossings were undertaken from behind parked vehicles or not. A high proportion of those crossing from behind a parked vehicle experience delay at the offside of the parked vehicle (85.8%), compared to 14.2% who did not cross from behind a parked vehicle (table 4.47).

Table 4.46a Position of Delays, Bruntsfield Place.

Position of Delay	Number of Pedestrians*
Gutter of Road	150
Offside of Vehicle	171
In Effective Carriageway	85

Note
* Delay could be experienced at one or more location for each pedestrian observed crossing.

Table 4.46b Delay Position, Raeburn Place.

Delay Position *Sample Number*[1]	Pedestrians Experiencing Delay *312* %
Gutter	28.5
Kerb	9.6
Shelter Offside of Parked Vehicle	56.7
In Effective Carriageway within 2 Metres of Parked Vehicle	5.2

Note
[1] Sample number refers to number of pedestrians

Table 4.47 Delay Position and Crossing from Behind a Parked Vehicle, Raeburn Place.

Delay Position	Sample Number[1]		Crossing from Behind a Parked Vehicle	Not Crossing from Behind Parked Vehicle
Gutter	89	%	34.8	65.2
Offside Shelter of Parked Vehicle	177	%	91.0	9.0
No Delay	203	%	50.2	49.8

Note
[1] Sample number refers to number of pedestrians.

4.3.10 Crossing ratios

The crossing ratio is defined as the ratio expressed as a percentage of those crossing divided by total pedestrian flows. It is a measure of crossing activity with a control for the overall levels of activity existing at that time. The calculation of the ratios used the crossing and pavement flow data discussed in chapter 3 (for respective sample sizes see appendix 3). Overall crossing ratios, for both pavements, on both Raeburn Place and Bruntsfield Place, are markedly lower for both children and the elderly than for adults (table 4.48), at 0.2% (for children) and 0.6% (for the elderly) compared to 13% for adults on Bruntsfield Place, while on Raeburn Place the ratios are slightly higher at 1% (for children) and 1.8% (for the elderly) compared to 19% for adults. The generally lower ratios for Bruntsfield Place may reflect a higher barrier effect associated with the greater road width and the different levels of platooning. This pattern is also found when the ratios are disaggregated by crossings undertaken from the different sides of the street.

Table 4.48 Crossing Ratios, Raeburn Place and Bruntsfield Place.

Age	Crossing Ratios Bruntsfield Place (%)	Crossing Ratios Raeburn Place (%)
Under 18	0.2	1.0
18-65	13.0	19.0
Over 65	0.6	1.8

The lower crossing ratios for the elderly and children reflect a tendency for these age groups to move through the street section or to make less crossings at informal locations (table 4.49 and 4.50). There may be a number of reasons for this, reflecting different trip making patterns and destinations, in addition to problems associated with crossing and perceptions of low levels of safety on tenemental radial routes.

Crossing ratios for the elderly and especially children were found to increase at the Pelican crossing in Raeburn Place (table 4.50) (for sample sizes see appendix 3). For example, on Tuesday, the crossing ratio for children at the Pelican crossing increased from 0.9% to 1.9% on the northern pavement, and from 1.2% to 3% on the southern pavement. This is as expected given that the young and elderly experience larger delays and tend to cross into larger acceptance gaps than adults. Even with the Pelican crossing however, crossing ratios are still low for the elderly and children, and this suggests that there is an under provision of crossing locations which are perceived as being safe, since there is no obvious reason why the elderly and children need to cross less. The lower crossing ratios for these age groups reflect perceived low safety levels and high levels of crossing difficulty. In the findings from the survey work discussed in chapter 5, a large proportion of elderly and young pedestrians felt unsafe (31.6% and 63.4% respectively) and felt crossing was difficult (68.4% of respondents aged under 18 and 73.1% of respondents aged over 65).

This finding may also reflect other factors related to facility location. Low levels of crossing activity for these age groups could reflect the locations of relevant facilities in adjacent areas which can be reached by not crossing Raeburn Place. Analysis indicates that age differences in crossing destination may be responsible for the lower crossing ratios for the elderly and young (table 5.41 p258). Suitable alternative locations for crossing en route to school or college for example, in the case of children, may be available outwith Raeburn Place. The low levels of child crossing activity recorded in the video survey may have been due to a school holiday.

Table 4.49 Crossing Ratios, Both Pavements, Bruntsfield Place.

Age	Crossing Ratio Eastern Pavement (%)	Crossing Ratio Western Pavement (%)
Under 18	0.2	0.2
18-65	16.6	11.1
Over 65	0.4	0.8

Table 4.50 Overall Crossing Ratios, Tuesday, Both Pavements, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Crossing Ratio Street Section (%)	Crossing Ratio Pelican Crossing (%)	Crossing Ratio Street Section (%)	Crossing Ratio Pelican Crossing (%)
Under 18	0.9	1.9	1.2	3.0
18-65	20.6	10.1	26.0	10.9
Over 65	2.1	2.0	2.5	2.4

Table 4.51 Actual Crossing Destinations, Video Survey, Raeburn Place.

Crossing Destination *Sample Number*[1]	Proportion Crossings to Actual Destination *515* %
Bus Stop	8.9
Shops	22.3
Parked Car	5.0
No Destination in Street Section	63.7

Note
[1] **Sample number refers to number of pedestrians.**

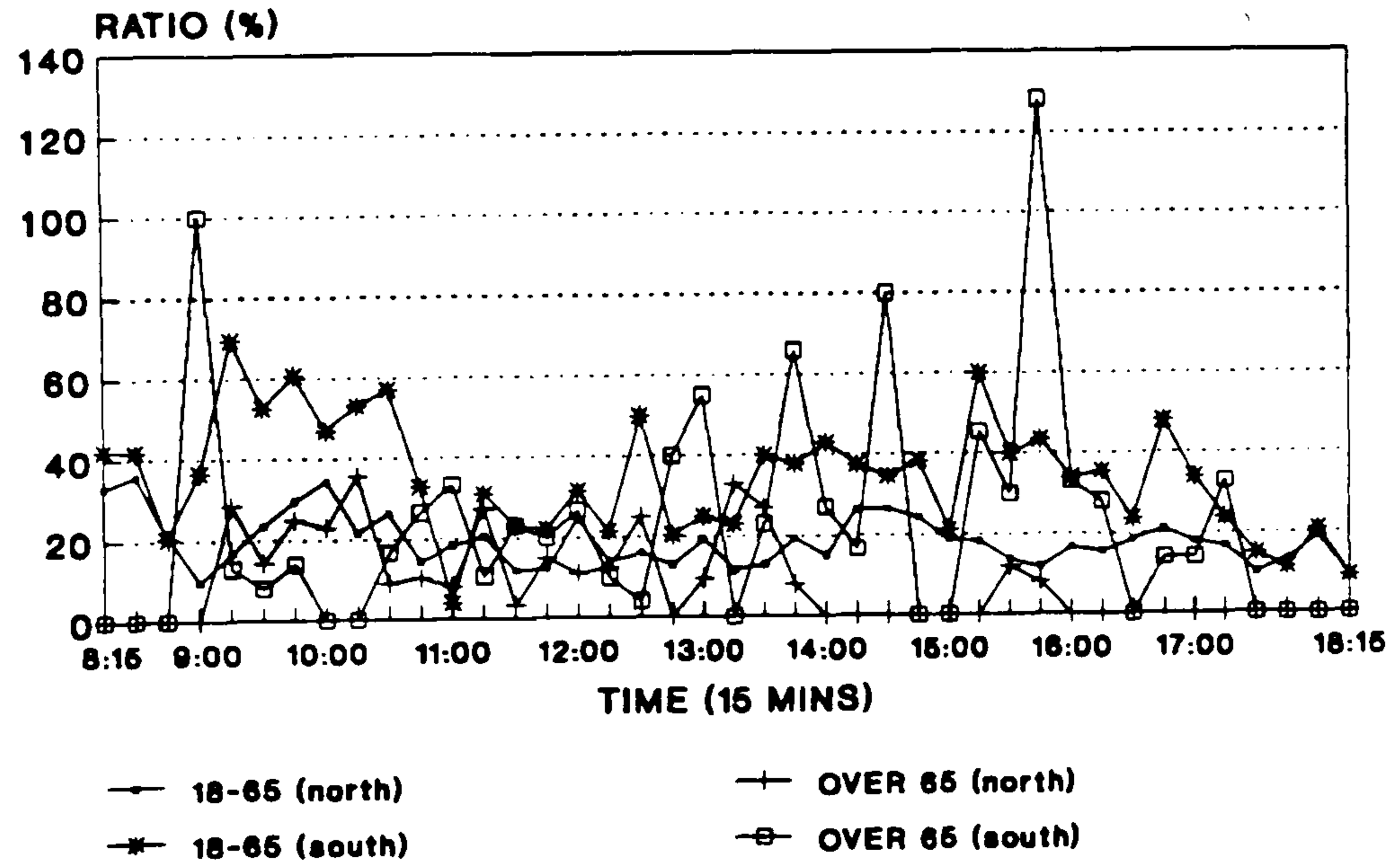
Crossing ratios also indicate differences in crossing activity levels between north and south pavements on Raeburn Place, and west and east pavements on Bruntsfield Place. These differences in crossing activity are linked to the location of more intensive retail activities on the northern pavement in Raeburn Place and on the eastern pavement in Bruntsfield Place, so that pedestrians are encouraged to cross disproportionately to these retail activities. This data therefore reflects local differences in circulation patterns.

Key attractors of pedestrian activity on tenemental-radial routes include shops and bus stops. Video analysis of actual crossings on Raeburn Place revealed that 22.3% were made to shops on the other side of the street (table 4.51), and 53% of respondents in the residents survey stated that the shops were often a crossing destination on a walking trip along (table 5.41 p258). Bus stops were also found to be an important crossing destination in both surveys, accounting for 8.9% of actual crossings in the video survey and 13.8% of stated destinations in the questionnaire survey. The location of educational facilities, schools, colleges and cashpoint machines in nearby areas may also result in an increase in the need to cross.

Trip type and its associated importance when linked with perceptions of safety and of traffic conditions influence the effects of the traffic barrier. Certain trip types are concentrated in certain periods of the day; for example, journeys to and from school and shopping journeys over the lunch and early to mid-afternoon periods. As a consequence, shifts in crossing activity may occur at different times according to trip type. Only a limited time of day analysis was possible however, due to the small numbers of crossings undertaken by the under 18 and over 65 age groups, and this was compounded by the fact that the video survey coincided with school holidays.

Analysis of crossing ratio data, by time of day, was therefore undertaken for Raeburn Place on Thursday only, with the omission of the under 18 age group. This revealed peaks in crossing ratios from around 0930 and 1030 in the morning and from 1500 to 1600 in the afternoon. During these periods, associated principally with shopping activity, crossing ratios for the southern pavement were noticeably higher (figure 4.7). The variation in crossing ratios, by time of day, associated with different activities, is of interest when examining shifts in crossing activity which occur at different times during the day in response to the traffic barrier effect.

Figure 4.7 Crossing Ratio by Time of Day, Thursday, Raeburn Place.



Analysis earlier in this chapter has noted the effects that traffic flow has on crossing behaviour and as a consequence, the crossing ratio is clearly affected, especially in the case of the young and elderly age groups. The analysis of crossing ratios in association with traffic flow data based on 15 minute aggregate traffic flow counts was not undertaken in this study, due to problems associated with the manipulation of different databases. Such an analysis would be problematic as it is difficult to relate behaviour to 15 minute flow counts, this is due to the variations in traffic conditions within the 15 minute count period which often results from the effects of platooning on central area urban streets. It is likely that crossing ratios will need to be monitored over substantial periods of time, in order to generate a sufficient number of pedestrian crossings. Further work needs to address the issue of the variation in pedestrian activity, this has implications for count period sizes, and for pedestrian flow, which can be used in the calculation of the crossing ratio.

Further work needs to be undertaken in order to assess the impact of the number of parked vehicles on crossing ratios. This study did not record parking activity levels in relation to the pedestrian flow counts. Parking activity was recorded only in the video survey of pedestrian behaviour. The pedestrian behavioural sample in this survey was collected on the basis of age stratification and not stratification by time of day. Crossing ratios need to be recorded by time of day in association with traffic flow and parking levels to allow controls over time of day effects to be introduced in relation to crossings from behind parked cars. This would help in assessing whether or not the high proportion crossing from behind parked vehicles corresponds with high levels of parking at high flow level times.

4.4 SUMMARY OF FINDINGS

Walking situation

Levels of accompaniment were found to be high for the under 18 age group by comparison with other age groups. Higher levels of accompaniment of children are associated with the perceived threat of traffic, and relatively high levels of crossing difficulty. Levels of accompaniment were found to increase during time periods in which traffic levels are relatively high.

Pedestrian delay

Total crossing time for all age groups is strongly dependent on kerb delay. A wide range of delays are experienced by pedestrians on both case study streets: from a minimum of 1 second to a maximum of 56 seconds. On both streets substantially larger delays are experienced by the young, elderly, and those accompanied. Traffic conditions, therefore, are particularly unfavourable to crossing activity for children and the elderly, who are unable to avoid relatively long delays at the kerb.

Pedestrian delay is principally affected by nearside carriageway traffic flow and to a lesser extent by farside traffic flow. Young and elderly pedestrians were found to be particularly affected by traffic flow in the nearside carriageway. Traffic speeds by comparison have little effect and is negatively correlated: delays increasing as speeds fall. Regression analysis indicated that total traffic flow, although accounting for only 15% of the variation in delay, is a significant predictor of delay. The dominating influence of traffic flow particularly on kerb delays for child and elderly pedestrians was also evident. The addition of traffic speed in to the regression equations, although making a statistically significant contribution did little to explain any additional variation in kerb delay.

Longer pedestrian delays were found to be related to heavy traffic flows, shorter acceptance gaps in the farside carriageway and steeper crossing angles. This indicates that pedestrians limit further increases in crossing time by adopting crossing strategies which incorporate steeper crossing angles into shorter acceptance gaps. A large proportion of delays were experienced at locations in the shelter of the offside of a parked vehicle.

Acceptance gaps

Both carriageways were found to exhibit a wide range of acceptance gaps, although average acceptance gaps for Raeburn Place were found to be much larger than those in Bruntsfield Place. This may reflect the different sample structures and the higher levels of platooning on Raeburn Place due to the traffic signals at junctions at either end and the operation of Pelican crossings.

Acceptance gaps are principally associated with the traffic speed and flow relationship in each carriageway at the time of crossing: as traffic flows increase and speeds lower, acceptance gaps become smaller. For all age groups traffic flow conditions have a significant impact on acceptance gaps, while traffic speed and flow levels at the time of crossing appear to have a greater impact on acceptance gaps for female pedestrians and those crossing accompanied.

Regression analysis also indicated that traffic flow makes a major contribution in determining pedestrian gap acceptance. Results indicated that traffic flow explained a substantial proportion of the variation in acceptance gaps for both carriageways (11% nearside and 23% farside). The introduction of traffic speed into the regression analysis produced a significant, but small, increase in prediction for both carriageways.

The low level of explanation reflects wide variations in individuals behaviour and fitness. For adults and those aged under 18 it is clear that speed makes an independent contribution in terms of choice of acceptance gaps. Results for the elderly suggest very little or no improvement in prediction with the introduction of traffic speed into the equation. This is perhaps related to lower levels of fitness, perception and vision, reducing the ability of this age group to respond to variations in speed.

Crossing angles

Pedestrians were found to cross steep angles generally, with even steeper crossing angles recorded for children, for the elderly and for those who cross accompanied rather than those crossing alone. Steeper crossing angles are associated with increased kerb delay and nearside carriageway traffic flows, and reductions in farside carriageway traffic speed: conditions associated with a relatively high traffic barrier. Clearly, steep crossing angles are taken to reduce exposure time in the carriageway.

Crossing angles for the elderly were found to be significantly associated with kerb delay and the number of parked vehicles present in the street at the time of crossing. This suggests that the number of parked vehicles may increase crossing angles by limiting the choice of crossing location and destination points on the other side of the carriageway, or that this group choose to cross this way, reducing exposure, when the barrier is at its highest.

Crossing from behind parked vehicles

The majority of crossings were undertaken from behind parked vehicles on both streets: 62.1% on Bruntsfield Place and 60.6% on Raeburn Place, with no significant difference between age groups in terms of whether they crossed from behind a parked vehicle or not. Pedestrians crossing from behind parked vehicles were found to cross at steeper angles. A high proportion of crossings undertaken from behind parked vehicles are associated with heavy traffic flow levels, low speeds and shorter acceptance gaps in the nearside carriageway. This suggests that crossing from behind a parked vehicle is related to attempts by pedestrians to mediate the traffic barrier effect. However, it is not clear whether the high proportion crossing from behind parked vehicles simply reflects the higher level of parking at times of higher flow.

Results suggest that pedestrians crossing in the shelter of the offside of a parked vehicle adopt this crossing strategy when flows are at their highest. Pedestrians crossing at this location therefore will maximise reductions in the traffic barrier and reduce their exposure time to risk. Evidence also indicates that the elderly and young are more likely to achieve greater benefits in terms of shallower crossing angles in comparison to the adult age group, by crossing from behind parked vehicles. This crossing strategy may also be forced upon pedestrians when coping with high levels of parked vehicles. More studies of crossing behaviour are therefore needed to control for parking levels in the analysis of crossings undertaken from behind parked vehicles.

Crossing ratios

Crossing ratios were found to be much lower for both children and the elderly than for other adults, reflecting a clear tendency for those age groups to move through the street sections or to make less crossings at informal locations. Crossing ratios for the elderly and especially children were found to increase at a formal crossing facility. However, even these increased ratios were still relatively low, yet there is no obvious reason why the elderly and children should need to cross less. Evidence indicates that perceptions of safety associated with traffic conditions may encourage crossing at formal locations. However, the low crossing ratio associated with the elderly and young could be accounted for by differing trip making patterns and journey characteristics of these age groups.

Crossing ratios to sides of the street where more intensive retail activity is located were relatively high, indicating that the traffic barrier will be experienced to a greater degree by pedestrians on street sections where major pedestrian trip attractors are located. Crossing ratios were found to be a useful tool in measuring variations in crossing activity and barrier effects.

Analysis of crossing ratios by time of day, although limited, revealed that this was a useful method by which shifts in crossing activity, by trip type, could be assessed. Linkages between traffic flow, parking density and the crossing ratio were not explored in this study due to problems associated with the data at the 15 minute aggregate level, and the unavailability of parking data for corresponding time periods. Further work needs to be undertaken to address these relationships.

4.5 CONCLUSIONS

Findings from the behavioural analysis indicate that the extent of the traffic barrier experienced by pedestrians on main central area urban streets is primarily influenced by traffic flow and to a lesser extent by speed conditions existing in the carriageway at the time of crossing. Regression analysis focused on kerb delay and acceptance gaps, variables which had been identified as being of the most interest following bivariate analysis. The regression equations as established, however, could not explain most of the variation in pedestrian delay and acceptance gaps. This is due to the fact that many of the relationships discussed are not linear, and that there are wide variations in mobility resulting from individual abilities (which are often compounded by age and health factors) and in traffic conditions at different crossing locations at different times.

Nonetheless, heavy traffic flows and low traffic speeds, were found to produce corresponding increases in kerb delay, steep crossing angles, short acceptance gaps, increased total crossing times and accounted for low crossing ratios, particularly amongst children and the elderly. Variations in the impact of traffic flow upon pedestrian behaviour were found based on pedestrian age, walking situation, trip type and importance.

A large proportion of crossings were shown to occur from behind parked vehicles during periods associated with high traffic flow levels. Analysis also indicated that reduced traffic flow levels and relatively high traffic speeds produced smaller delays at the kerb, shallower crossing angles, larger acceptance gaps, reductions in total crossing time, and associated reductions in the proportions of pedestrians crossing from behind parked vehicles.

Analysis of the crossing ratio measure and patterns of pedestrian crossing activity highlight the need in traffic barrier studies to consider factors other than traffic conditions. Factors associated with facility location, trip purpose and importance may also contribute to differnces in crossing activity and behaviour. There is also clearly a need for behavioural studies to be supplemented by questionnaire and in-depth surveys so that reasons for behaviour changes and associated perceptions of risk and safety can be explored.

CHAPTER 5 ANALYSIS OF QUESTIONNAIRE SURVEYS

5.1 INTRODUCTION

Previous research, reported in chapter 2, has indicated that changes in behaviour are mediated by perceptions of the surrounding street environment. Such perceptions are important in that it is subjective perceptions of the objective traffic conditions moreso than the objective conditions themselves which are likely to influence behaviour. The study of perceptions of street environments is therefore a valuable supplement to studies of observable pedestrian behaviour in studying the traffic barrier effect. The questionnaire surveys reported here were conducted to complement the video analysis reported in chapter 4 in order to identify perceptual factors associated with changes in pedestrian behaviour in different traffic conditions. The questionnaire was designed to assist in the testing of hypotheses related to the perception of traffic flow levels and their effect on pedestrian behaviour characterised by:

1) perceived conditions for pedestrians associated with particular features of the street;

2) levels of perceived safety;

3) choice of crossing location; and

4) route choice, discouragement and deterrence.

In addition, the survey was used to assess the role of kerbside parking in relation to:

1) the perception that crossing into gaps in the oncoming traffic stream was made easier; and that this;

2) increased feelings of safety and security.

This survey approach was however recognised to have several limitations, in that the respondents were constrained to the set format of the questionnaire, and because the link between perceptions, behavioural response and objective traffic conditions was left unexplored by this approach. These limitations are discussed further in the conclusions at the end of the chapter.

Two questionnaires were devised for the initial study of Bruntsfield Place, one for residents and one for on-street pedestrians. They were designed to obtain the necessary data on pedestrian activity patterns; pedestrian and resident perceptions of the street environment and their variation by time of day; and on how these perceptions may in turn affect behaviour and activity patterns by time of day. Questions asked fell into several sections on both questionnaires (see appendix 1 for the questionnaire forms). These were: 1) personal details - age , sex, place of abode; 2) walking and activities carried out in the street; 3) street amenity; 4) assessment of traffic conditions in the street; 5) belief and value assessment (for residents only); 6) possible improvements to the pedestrian environment (for residents only).

The residents' questionnaire was delivered by hand to individuals in each flat who agreed to take part in the survey along Bruntsfield Place and the number of forms dropped off were recorded on a check list. This proved useful in increasing the sample size when the questionnaires were collected, as those households which had not been contacted were readily identifiable from the checklist. A maximum of 4 unsuccessful visits to each household was used as the threshold before the address was abandoned and excluded from the survey.

The on-street questionnaire was carried out over 3 days by a team of trained interviewers who had been familiarised with the questionnaire format and the way in which responses were to be elicited from respondents. Each individual member of the team was given a target number of interviews for each age group which had to be completed within the selected analysis periods. These were (1) 0800-0915 (2) 1130-1330 (3) 1500-1730 (4) 1845-2000. However, the desired targets proved hard to achieve over the 3 days allocated. Firstly, due to the low numbers on street in the under 18 and over 65 age groups, and secondly, due to the adverse weather conditions at the time of survey.

For the second study of Raeburn Place, only a residents survey was used due to the fact that responses from both the resident and on-street surveys in the initial study were similar. A resident survey also guarantees a higher quality of response due to the fact that residents will be able to spend more time on their forms and subsequently, the level of detail of the responses will be greater than could be obtained on-street.

For the second study, the questionnaire form was modified to address particular aspects of crossing behaviour. This involved the collection of more detailed information highlighting:

1) the problems associated with the traffic conditions and crossing the road;

2) origins and destinations of pedestrian routes and trip diversions;

3) crossing strategies, with questions referring to actual performance rather than knowledge of safe behaviour.

Analysis of the results from the three set format questionnaire surveys undertaken on Raeburn Place and Bruntsfield Place are referenced back to the questionnaires in appendix 1. This permits cross checking with the wording of the questions used. Questions relating to "Form A" refer to the Bruntsfield Place residents survey, while questions from "Form B" refer to the on-street survey of Bruntsfield Place and questionnaire "Form C" the residents survey on Raeburn Place.

5.2. AGE AND SEX CHARACTERISTICS

From the residents' survey of Bruntsfield Place, a response rate of 52.9% was obtained, with a total of 147 questionnaires returned out of 278. For the Raeburn Place residents survey, a response rate of 51.7% was obtained; 181 responses from 350 questionnaires. Table 5.1 shows the age/sex breakdown of the respondents for both residents surveys. In both surveys, the 18-65 age group was found to be dominant while those in the under 11, 11-18, and over 65 age groups were somewhat under represented. For the Raeburn Place survey, the under representation of the over 65s was remedied by further survey work in order to build up the numbers of respondents in that age group. This involved the dropping off and collection of questionnaire forms from Stockbridge House, an old peoples centre run by the Edinburgh and Old People's Welfare Council. The samples constructed in the questionnaire surveys represent the variation in perceptions and the differential impact of traffic conditions on different age groups. The samples are therefore not representative of the populations residing or walking, in the case of the on-street survey, on these streets.

Table 5.1 Age/Sex of Respondents, Raeburn Place and Bruntsfield Place, residents surveys.

	Raeburn Place		Bruntsfield Place	
Age	**Male (%)**	**Female (%)**	**Male (%)**	**Female (%)**
Under 18	5 (6.5)	14 (13.5)	1 (1.5)	3 (3.8)
18-24	17 (22.1)	24 (23.1)	24 (35.8)	34 (42.5)
25-65	32 (41.6)	42 (40.4)	41 (61.2)	38 (47.5)
Over 65	23 (29.9)	24 (23.1)	1 (1.5)	5 (6.3)
Total	77	104	67	80

In both of the residents, surveys a slightly larger number of responses from females was obtained; 80 females compared to 67 from males in the Bruntsfield Place survey, and 104 females compared to 77 males in the Raeburn Place survey. A total of 170 responses (and 61 refusals) was obtained for the on-street questionnaire undertaken on Bruntsfield Place. The largest age group was the 18-65 age group, which accounted for 68.5% of males and 69.1% of females.

In the Raeburn Place survey, the variable 'employment status' was added, but analysis revealed no significant difference between the sexes in terms of employment status.

5.3 PEDESTRIAN TRIP CHARACTERISTICS

5.3.1 Frequency of Walking Trips

Most of those residents surveyed indicated that they walked along Bruntsfield Place and Raeburn Place on a relatively frequent basis, 1 trip a day or more (88.9% on Bruntsfield

Place and 60.8% on Raeburn Place) (table 5.2). In the Raeburn Place survey, a larger proportion of respondents stated that they used the street on a more infrequent basis. The on-street survey of pedestrians on Bruntsfield Place found, not surprisingly, that pedestrian trip frequency was not as high for residents, with 51.1% of those surveyed on-street making 1 or more trip a day along Bruntsfield Place.

Table 5.2 Trip Frequency on Raeburn Place and Bruntsfield Place.

Trip Frequency *Sample Number*[1]	Bruntsfield Place Residents Survey *147* %	Bruntsfield Place On-Street Survey *170* %	Raeburn Place Residents Survey *181* %
Less than 1 Trip a Week	00.0	11.2	3.9
1-2 Trips a Week	00.7	15.3	12.2
3-5 Trips a Week	10.2	22.4	23.2
1 Trip a Day	23.8	18.2	23.2
2 Trips a Day	35.4	14.1	22.1
More than 2 Trips a Day	29.7	18.8	15.5

Note
[1] Sample number refers to number of respondents.
Results refer to "trip frequency" question 3 (Form A), question 1 (Form C) and question 6 (Form B). (All questionnaire forms appear in Appendix 1).

No significant differences in trip frequencies were found between either of the sexes, while crosstabulation of age and employment status by frequency of walking trip were found to be significant. 40.4% of those aged over 65 made infrequent trips along Raeburn Place, that is up to 2 trips a week, while 29.7% and 29.3% of those aged 25-65 and 18-24 made 1 walking trip a day. Respondents aged under 18 made the most walking trips along Raeburn Place (table 5.3). Respondents with no employment were found to use the street more infrequently (appendix 3).

Table 5.3 Trip Frequency and Age, Raeburn Place.

Age of Respondent				
Trip Frequency	**Under 18**	**18-24**	**25-65**	**Over 65**
Sample Number[1]	*19* %	*41* %	*74* %	*47* %
Up to 2 Trips a Week	**5.3**	**9.8**	**6.8**	**40.4**
3-5 Trips a Week	**10.5**	**26.8**	**24.3**	**23.4**
1 Trip a Day	**15.8**	**29.3**	**29.7**	**10.6**
2 Trips a Day	**42.1**	**22.0**	**24.3**	**10.6**
Over 2 Trips a day	**26.3**	**12.2**	**14.9**	**14.9**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 1 "trip frequency" and question 25 "age" (Form C, Appendix 1).

5.3.2 Reasons for going out as a Pedestrian

The largest proportion of the pedestrian trips made by residents on Bruntsfield Place were for shopping/to or from work (29.1%) and to or from school or college (23.4%) (table 5.4). Substantially smaller numbers of trips were recorded for personal business (3.5%), meeting friends (2.1%), or leisure (2.1%) - all optional activities. It would therefore seem that Bruntsfield Place is used by residents for mainly essential activities. The on-street survey of Bruntsfield Place also revealed the large numbers of journeys made by pedestrians to or from school or college (32.5%), and shopping (26%), and work (13%). As with the residents survey, there are relatively smaller numbers of people using Bruntsfield Place for optional/leisure activities. The Raeburn Place survey revealed that shopping accounted for the largest proportion of pedestrian trips (33.1%), while trips to or from work (19.3%) and trips to or from school/college (16.6%) accounted for smaller proportions. As with Bruntsfield Place, Raeburn Place is used mainly for essential purposes - personal, leisure, and meetings with friends account for only a small proportion of trips (4.4%, 5%, and 2.2% respectively) (table 5.4).

Table 5.4 Reasons for going out on Bruntsfield Place and Raeburn Place.

Reason for Pedestrian Trip ***Sample Number*** [1]	**Bruntsfield Place Residents Survey** *141* %	**Bruntsfield Place On-Street Survey** *169* %	**Raeburn Place Residents Survey** *181* %
Shopping	**13.5**	**26.0**	**33.1**
Shopping to or from Work	**29.1**	**1.8**	**11.0**
To or from Work	**13.5**	**13.0**	**19.3**
Part of Work	**0.0**	**4.7**	**2.8**
To Car or another form of Transport	**12.8**	**1.2**	**3.9**
Personal Business	**3.5**	**9.5**	**4.4**
To or from School or College	**23.4**	**32.5**	**16.6**
Meeting Friends	**2.1**	**5.9**	**2.2**
Leisure	**2.1**	**5.3**	**5.0**
Take child to School	*	*	**1.1**

Note
[1] Sample number refers to number of respondents.
Results refer to question 6 (Form A), question 1 (Form B) and question 4 (Form C) "reasons for going out". (All questionnaire forms appear in Appendix 1).
*** Variable only used in the Raeburn Place survey.**

Trip purpose was found to be affected by age differences (table 5.5). Respondents aged under 18 and 18-24 were found to use Raeburn Place for trips to/from school or college (78.9% and 34.1% respectively). Not surprisingly, trips associated with the 25-65 age group were principally focused around shopping trips and journeys to/from work. By comparison, trips associated with the elderly were principally identified with shopping

(58.7%) and other journeys (34.8%). This consists principally of personal trips, meeting friends and leisure activities.

Table 5.5 Reasons for going out and Age, Raeburn Place.

	Age of Respondent			
Reason for Trip *Sample Number*[1]	**Under 18** *19* %	**18-24** *41* %	**25-65** *74* %	**Over 65** *46* %
Shopping	**15.8**	**14.6**	**32.4**	**58.7**
Shopping to or from Work	**0.0**	**14.6**	**16.2**	**4.3**
To or from Work	**0.0**	**19.5**	**35.1**	**2.2**
Other	**5.3**	**17.1**	**14.9**	**34.8**
To or from School or College	**78.9**	**34.1**	**1.4**	**0.0**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 4 "trip purpose" and question 25 "age" (Form C, Appendix 1).

5.3.3 Average Length in Time of Walking Trips

Residents on Bruntsfield Place and Raeburn Place were found to spend large amounts of time walking. The largest proportion of residents' pedestrian trips lasted for 10 to 20 minutes (32.4% on Bruntsfield Place and 42.5% on Raeburn Place) (table 5.6). Further analysis of the Raeburn Place data revealed that both sex and employment status have a significant impact on the average length of time spent walking. The largest proportion of men and women in this survey were found to walk for 10-20 minutes; 36.4% and 47.6% respectively, although there is a substantial difference in terms of the overall pattern. A larger proportion of women walk for over 30 minutes, 19.4% compared to 11.7% of men. A greater proportion of men appear to walk for less than 10 minutes, 26% compared to 10.7% of women (see appendix 3). For all categories of employment status, the modal category is for walking trips of 10-20 minutes duration: for those in full employment 52.6%, in part-time work 45.5%, no employment 31.8%, and students 45.7%. For those with some form of employment, full or part-time, a greater proportion of journeys last less than 10 minutes: 26.3% of those in full employment and 22.7% in part-time employment. Students, or those with no employment, spend longer periods of time walking, with the over 30 minutes category reading 14.3% and 28.8% respectively (see appendix 3).

Table 5.6 Average Length of Walking Trip Bruntsfield Place and Raeburn Place.

Average Length of Walking Trip (Mins)	**Bruntsfield Place**	**Raeburn Place**
Sample Number[1]	*147* %	*180* %
Less than 10	**23.6**	**17.1**
10-20	**32.4**	**42.5**
20-30	**23.6**	**23.8**
Greater than 30	**20.3**	**16.0**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 6 (Form C) and question 8 (Form A) "length of time of trip". (All questionnaire forms appear in Appendix 1).

Not surprisingly, a strong relationship was found between the length of time of a walking trip and the distance of a walking trip on Raeburn Place (see appendix 3).

Trip purpose was also found to have a bearing on average length of time spent walking. 62.1% of trips over 30 minutes and 51.2% of trips lasting 20-30 minutes were shopping trips, while trips to or from work were found to account for 35.5% of trips less than 10 minutes and 28.6% of trips lasting on average 10-20 minutes. 45.2% of trips less than 10 minutes were accounted for by the 'other' category. This included: meeting friends, leisure, personal, taking children to school, part of work and trips to the car or another form of transport (see appendix 3).

5.3.4 Average Distance of Walking Trips

Average distance of walking trips was included in the residents' questionnaire for Raeburn Place only, and in the on-street survey undertaken on Bruntsfield Place. A substantial proportion of journeys were between 50 yards and 1 mile, 64.1% in the case of trips by residents on Raeburn Place. 93.5% of respondents in the on-street survey resided in Edinburgh, and of these, the vast majority lived on streets over 50 yards and under 1 mile away from Bruntsfield Place (99%). Bruntsfield Place is therefore an important street locally.

Further analysis of the data revealed significant relationships between trip purpose and average distance of walking trips. 36.7% of trips over 1 mile and 36.2% of trips between 50 yards and 1 mile were accounted for by shopping trips, while 29.4% of trips under 50 yards were accounted for by trips to or from work (see appendix 3).

5.3.5 Car Availability

On both study streets, a substantial proportion of resident respondents stated that they had no car available to them, 60.3% on Bruntsfield Place and 69.1% on Raeburn Place. As would be expected, a high proportion of those who stated that a car was available to them were in the 25-65 age group: 73.2% on Bruntsfield Place and 69.1% on Raeburn Place. The proportion of women who stated that they did not have access to a car was greater than that for men: 62.4% compared to 37.6% in the Raeburn Place survey, while 56.4% of residents who stated that they had a car available to them were also in full employment (see appendix 3). These results clearly indicate the factors which contribute to having a car available to use: an adequate level of income, age and sex.

Car availability was not found to have a major impact on reasons why residents made trips as pedestrians in Bruntsfield Place; residents still used Bruntsfield Place predominantly for shopping/to or from work (34.5%) and journeys to and from work (20%). Despite this, 29.1% stated that they used the street to walk to the car or another form of transport. Residents who did not have a car available to them cited the main reasons for going out as pedestrians as shopping/to and from work (25.3%) and to and from school or college (34.9%). On Raeburn Place, a similar pattern was found with residents who had a car available to them still using Raeburn Place for shopping (20%) and for pedestrian trips to and from work (54.3%) (table 5.7). Only 3.1% stated that they used the street to get to the car or another form of transport. The smaller proportions citing shopping as a trip purpose on Raeburn Place may be explained by competition from a Safeway store, nearby, at Comely Bank (an extension of Raeburn Place) or the greater variety of retail outlets along Bruntsfield Place. The smaller proportion citing trip purpose to and from the car or another form transport, may well reflect the more severe lack of parking space in Raeburn Place and greater willingness to walk to work than residents on Bruntsfield Place.

Table 5.7 Trip Purpose and Car Availability, Bruntsfield Place and Raeburn Place.

	Bruntsfield Place		Raeburn Place	
Trip Purpose	**No Car Available**	**Car Available**	**No Car Available**	**Car Available**
Sample Number[1]	*83* %	*58* %	*125* %	*55* %
Shopping	**16.9**	**9.1**	**39.2**	**20.0**
Shopping To/From Work	**25.3**	**34.5**	**8.8**	**16.4**
To/From Work	**9.6**	**20.0**	**12.8**	**34.5**
To/From School/ College	**34.9**	**5.5**	**20.0**	**20.0**
Other	**13.2**	**36.4**	**19.2**	**9.1**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 7 "car availability" and question 6 "trip purpose" (Form A) and question 5 "car availability" and question 4 "trip purpose" (form C). (All questionnaire forms appear in Appendix 1).

5.4 CONDITIONS FOR PEDESTRIANS ON THE CASE STUDY STREETS

In the questionnaire surveys on Bruntsfield Place, residents and pedestrians on-street were asked to assess certain features of the street in terms of whether there were problems or not. Questions were also asked relating to levels of stress, risk, and safety experienced in Bruntsfield Place (see Appendix 1). Following completion and analysis of the data however, it was felt that this wording was too deterministic i.e. in defining aspects of the street as a problem (question 10 Form A and question 7 Form B in Appendix 1). For the Raeburn Place residents' survey, the wording of the question was changed so that respondents assessed conditions for pedestrians in Raeburn Place according to whether conditions were very bad or very good for each street feature (question 9 Form C in Appendix 1). Questions regarding safety, risk and stress were withdrawn in relation to descriptions of the conditions for pedestrians on the case study streets. Firstly, due to a high level of inter-correlation between the concepts of risk, stress and safety and secondly, due to definitional problems associated with the inability to practically ascribe meaning to these terms, as set out in the questionnnaire to aspects of the street environment (question 18 Form A and question 13 Form B Appendix 1). In the Raeburn Place survey, the concept of safety was explored directly in relation to crossing the road (question 18 Form C Appendix 1). Results are therefore discussed from each questionnaire survey separately.

5.4.1 Problems for pedestrians in Bruntsfield Place

In the Bruntsfield Place survey, residents were asked to indicate whether, as pedestrians, the following did or did not cause problems in Bruntsfield Place: parked cars; traffic conditions; crossing the road; obstructions on the pavement; traffic noise; and loading and unloading of vehicles. From the survey results it is clear that traffic related issues are major causes of problems for pedestrians in Bruntsfield Place: 62.5% found traffic conditions a bad problem (27.7% very bad and 4.8% bad); while 65.8% found crossing the road a bad problem (27.4% very bad and 38.4% bad). Other features were also seen as a bad problem but at relatively lower levels: parked cars 41.6%; pavement obstructions 25.1%; traffic noise 40.9%; and loading and unloading of vehicles 27.6% (table 5.8).

Table 5.8 Stated Conditions for Pedestrians, Residents' Survey, Bruntsfield Place.

Street Feature/ Condition	Sample Number[1]		Very Bad Problem	Bad Problem	Slight Problem	No Problem
Parked Cars	142	%	12.7	28.9	37.3	21.1
Traffic Conditions	141	%	27.7	34.8	29.8	7.8
Crossing the Road	146	%	27.4	38.4	23.3	11.0
Pavement Obstructions	139	%	8.6	16.5	38.8	36.0
Traffic Noise	144	%	20.8	20.1	34.0	25.0
Loading and Unloading	141	%	9.9	17.7	50.4	22.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 10 "street feature/condition" (Form A, Appendix 1).

The on-street survey produced similar results. As with the residents' survey, traffic issues were seen as major problems encountered by pedestrians: 60% found traffic conditions a bad problem (20% very bad and 40% bad); and 62.9% found crossing the road a bad problem (27.6% very bad and 35.3% bad). Other street features were also seen as a bad problem but to a lesser extent (appendix 3).

Further analysis of the on-street survey also revealed that the time of interview was a significant factor, in terms of the extent to which each street feature was seen as a problem for pedestrians. Parked cars were seen as a bad problem by pedestrians, particularly at 0800-0915 (39%) and 1500-1730 (31.5%), while at 1130-1330 and 1845-2000, the proportion of respondents stating parked cars as a bad problem was relatively low indicating slightly better conditions at these times. By comparison, crossing the road was seen as a bad problem by the majority of pedestrians throughout most of the day (Table 5.9a-b).

Table 5.9a Time of Interview and Extent to which Parked Cars were cited as a Problem for Pedestrians, On-Street Survey, Bruntsfield Place.

Time of Interview (hrs)	Sample Number[1]		Very Bad Problem	Bad Problem	Slight Problem	No Problem
0800-0915	41	%	4.9	39.0	34.1	22.0
1130-1330	46	%	13.0	10.9	43.5	32.6
1500-1730	54	%	18.5	31.5	16.7	33.3
1845-2000	29	%	6.9	27.6	44.8	20.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 7 "street feature/condition" and time of interview (Form B, Appendix 1).

Table 5.9b Time of Interview and Extent to which Crossing the Road was cited as a Problem for Pedestrians, On-Street Survey, Bruntsfield Place.

Time of Interview (hrs)	Sample Number[1]		Very Bad Problem	Bad Problem	Slight Problem	No Problem
0800-0915	41	%	34.1	43.9	12.2	9.8
1130-1330	46	%	23.9	39.1	26.1	10.9
1500-1730	54	%	35.2	31.5	25.9	7.4
1845-2000	29	%	10.3	24.1	44.8	20.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 7 "street feature/condition" and time of interview (Form B, Appendix 1).

Traffic noise and loading and unloading of vehicles were also seen as problems but to a lesser extent. For example, at 0800-0915, traffic noise was seen as a slight problem or no problem at all by 36.6% and 29.3% of respondents respectively. Similarly, loading and unloading of vehicles was seen as being a slight problem or no problem at all for most of the day by large proportions of respondents. This evidence suggests that perceptions and attitudes towards the street and consequently, behaviour, do vary through the day (appendix 3).

The residents' survey found that the sex of the respondent had a significant relationship with the degree to which crossing the road, pavement obstructions and traffic noise were problems. Female pedestrians found conditions consistently worse than their male counterparts. For example, only 21.2% of males compared to 31.6% of females stated that crossing the road was a very bad problem (table 5.10). Similarly, 48% of females found pavement obstructions were a slight problem compared to only 28.6% of males, while for traffic noise, 42.9% of females stated that traffic noise was a slight problem compared to 24.2% of males (appendix 3).

Table 5.10 Sex of Respondent and the Extent to which Crossing the Road was a Problem for Pedestrians, Residents' Survey, Bruntsfield Place.

Sex of Respondent	Sample Number[1]		Very Bad Problem	Bad Problem	Slight Problem	No Problem
Male	66	%	21.2	40.9	18.2	19.7
Female	79	%	31.6	36.7	27.8	3.8

Note
[1] Sample number refers to number of respondents.
Results refer to question 10 "street feature/condition" and question 2 "sex" (Form A, Appendix 1).

5.4.2 Conditions for pedestrians on Raeburn Place

In the Raeburn Place survey, residents were asked how they felt about certain features found in Raeburn Place as a pedestrian. This survey included a more specific definition of traffic conditions. "Traffic conditions" was rephrased so that separate responses could be elicited regarding traffic levels and traffic speed. Other features for which responses were elicited were: parked cars; pavement obstructions; traffic noise; loading and unloading of vehicles; and traffic fumes. Traffic levels and speed were seen by residents as being particularly bad: 66.3% cited traffic levels as being bad (23.8% very bad and 42.5% bad) and 49.7% thought traffic speed was bad in Raeburn Place (12.7% very bad and 37% bad). Other features were also seen to contribute towards creating adverse conditions for pedestrians by substantial minorities of respondents (table 5.11).

Table 5.11 Stated Conditions for Pedestrians, Residents' Survey, Raeburn Place.

Street Feature/ Condition	Sample Number[1]		Very Bad	Bad	Good Nor Bad	Good	Very Good
Parked Cars	179	%	23.2	33.1	37.6	5.0	0.0
Traffic Level	176	%	23.8	42.5	23.2	6.1	1.7
Pavement Obstruct.	174	%	12.2	29.8	38.1	15.5	0.6
Traffic Noise	174	%	14.4	18.8	39.8	19.3	3.9
Load/ Unload Vehicles	173	%	14.9	31.5	42.5	6.1	0.6
Traffic Speed	177	%	12.7	37.0	30.9	14.9	2.2
Traffic Fumes	172	%	15.5	25.4	32.6	17.7	3.9

Note
[1] Sample number refers to number of respondents.
Results refer to question 9 "street feature/condition" (Form C, Appendix 1).

Results from the Raeburn Place survey suggest that views of street conditions are not influenced by trip frequencies (table 5.12). Yet it seems that the least frequent trip maker on foot is more susceptible to citing that street conditions are bad. Of those pedestrians making up to only 2 trips a week (of large proportion of whom who are elderly), 79.3% stated that parked cars promoted bad conditions. Similarly, 75.9% stated that traffic levels also promoted bad conditions. Despite this, 76.2% of those pedestrians making 1 trip a day also felt that traffic levels promoted bad conditions. Although it may be the case that low levels of trip-making activity are linked to respondents' perceptions of adverse or bad conditions for pedestrians in the street, which may discourage trips on foot being made, evidence does indicate that the most frequent users are bothered by traffic levels and traffic fumes. This is logical in terms of higher levels of exposure to health risks.

Table 5.12 Bad Street Conditions According to Trip Frequency, Residents' Survey Raeburn Place.

Street Feature/ Condition *Sample Number[1]*	% Stating Up to 2 Trips a Week and Bad Conditions *29*	% Stating 3-5 Trips a Week and Bad Conditions *42*	% Stating 1 Trip a Day and Bad Conditions *42*	% 2 Trips a Day and Bad Conditions *40*	% Stating Over 2 Trips a Day and Bad Conditions *28*
Parked Cars	79.3	61.9	40.5	52.5	53.6
Traffic Level	75.9	57.1	76.2	55.0	71.4
Pavement Obstruct -ions	69.0	42.9	31.0	30.0	46.4
Traffic Fumes	34.5	26.2	31.0	50.0	74.4

Note
[1] Sample number refers to number of respondents.
Results refer to question 9 "street feature/condition" and question 1 "trip frequency" (Form C, Appendix 1).

Average length of walking trip (time), average distance of walking trip and car availability were found to be insignificant indicators as to whether these street features were assessed as being good or bad.

Table 5.13 Bad Street Conditions and the Age of Respondents, Residents' Survey, Raeburn Place.

Street Feature/ Condition *Sample Number*[1]	% of those aged 0-18 and Stating Bad Street Conditions *19*	% of those aged 19-24 and Stating Bad Street Conditions *41*	% of those aged 25-65 and Stating Bad Street Conditions *74*	% of those aged Over 65 and Stating Bad Street Conditions *46*
Parked Cars	**36.8**	**26.8**	**32.4**	**39.1**
Traffic Level	**57.9**	**46.3**	**39.2**	**39.1**
Pavement Obstruction	**36.8**	**17.1**	**39.2**	**71.7**
Traffic Noise	**36.8**	**26.8**	**25.7**	**50.0**
Traffic Fumes	**47.4**	**15.0**	**43.2**	**58.7**
Traffic Speed	**68.4**	**31.7**	**41.9**	**71.7**

Note
[1] Sample number refers to number of respondents.
Results refer to question 9 "street feature/condition and question 25 "age" (Form C, Appendix 1).

Substantial proportions of respondents, of all age groups, felt that conditions for pedestrians in Raeburn Place were bad, especially with regard to traffic speeds and traffic levels. Residents aged under 18 and over 65 in particular, appeared to feel that traffic speed, traffic fumes, traffic noise and parked cars were particularly bad in Raeburn Place. In addition, 71.7% of elderly respondents found that pavement obstructions were also bad for pedestrians on Raeburn Place (table 5.13).

Although 37.4% of respondents stated that conditions for pedestrians in Edinburgh were good, a similar proportion, 33.5%, also stated that conditions were bad. A much greater proportion of respondents, however, felt that conditions were particularly bad for pedestrians on Raeburn Place; 47.1% compared to the 27.7% who stated that conditions were good (table 5.14). Significant associations were found between conditions on Raeburn Place and frequency of walking trips and car availability. For all levels of trip frequency substantial proportions of respondents felt that conditions for pedestrians were bad. For example, of those respondents who stated that they made only up to 2 trips a week along Raeburn Place, 72.4% stated conditions were bad for pedestrians on Raeburn Place. However, the proportions of respondents who stated that they found conditions neither good nor bad or good increased with trip frequency (table 5.15). So, again, the more often journeys are made on foot, conditions for pedestrians on Raeburn Place, and related barrier effects, are seen to be less of a problem. This observation is likely, in part, to be a reflection of the large numbers of elderly who make up to 2 journeys a week, and who find conditions for pedestrians relatively worse than respondents in younger age groups anyway.

Respondents who had no car available to them tended to state that conditions in Edinburgh and Raeburn Place were slightly less favourable for pedestrians than those who did have access to a car. 40% of those who stated that they did have a car available, stated that conditions for pedestrians in Raeburn Place were bad (9.1% very bad and 30.9% bad), compared to 50.4% who had no car available (24.8% very bad and 25.6% bad) (table 5.16). Car availability clearly has an impact on the extent to which pedestrian environments are seen as good or bad, with differences in the very bad category being particularly marked.

Table 5.14 Conditions for Pedestrians in Edinburgh and Raeburn Place, Residents' Survey, Raeburn Place.

Conditions	% Stating Conditions for Pedestrians in Edinburgh	% Stating Conditions for Pedestrians on Raeburn Place
Sample Number[1]	*179*	*181*
Very Bad	13.4	19.9
Bad	20.1	27.1
Neither Good Nor Bad	29.1	25.4
Good	36.3	27.1
Very Good	1.1	0.6

Note
[1] Sample number refers to number of respondents.
Results refer to question 10 "conditions for pedestrians in Edinburgh" and question 11 "conditions for pedestrians in Raeburn Place" (Form C, Appendix 1).

Table 5.15 Street Conditions for Pedestrians According to Trip Frequency, Residents' Survey, Raeburn Place.

	Trip Frequency				
Conditions	Up to 2 Trips a Week	3-5 Trips a Week	1 Trip a Day	2 Trips a Day	Over 2 Trips a Day
Sample Number[1]	*29* %	*42* %	*42* %	*40* %	*28* %
Very Bad	41.4	19.0	11.9	10.0	25.0
Bad	31.0	26.2	26.2	27.5	25.0
Good Nor Bad	10.3	26.2	31.0	40.0	10.7
Good	17.2	28.6	31.0	22.5	39.3

Note
[1] Sample number refers to number of respondents.
Results refer to question 11 "conditions for pedestrians on Raeburn Place" and question 1 "trip frequency" (Form C, Appendix 1).

Table 5.16 Car Availability and Stated Conditions in Edinburgh and Raeburn Place for Pedestrians, Residents' Survey, Raeburn Place.

	Conditions in Edinburgh		Conditions in Raeburn Place	
Stated Condition	**Car Available**	**No Car Available**	**Car Available**	**No Car Available**
Sample Number[1]	*54* %	*124* %	*55* %	*125* %
Very Bad	**1.9**	**18.5**	**9.1**	**24.8**
Bad	**24.1**	**18.5**	**30.9**	**25.6**
Neither Good Nor Bad	**33.3**	**27.4**	**32.7**	**21.6**
Good	**40.7**	**35.5**	**27.3**	**28.0**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 10 "conditions in Edinburgh for pedestrians", question 11 "conditions for pedestrians in Raeburn Place" and question 5 "car availability" (Form C, Appendix 1).

5.4.3 Perceived traffic flow and stated effects

From the surveys of residents on both Raeburn Place and Bruntsfield Place, it is clear that certain time periods are associated with perceptions of relatively heavy, medium, and light traffic flows. Consequently, attitudes towards traffic levels are found to vary over the day. This supports findings from the behavioural analysis which indicated that crossing behaviour varies in response to traffic levels. Exhibited behaviour patterns therefore appear to reflect perceptions. The perceived traffic flow pattern obtained from both residents' surveys, is as set out in table 5.17 below, where the percentages indicate the proportions of residents who described the traffic flow as having the stated characteristic. These results appear to reflect variations in the actual flow counts obtained from the video for each time period (see figure 4.10).

Table 5.17 Description of Traffic Flow by Time Period, Bruntsfield Place and Raeburn Place

Time *Sample Number*[1]	Bruntsfield Place (% of Respondents) *148*	Raeburn Place (% of Respondents) *181*
0800-0930	Heavy 91.9 Medium 2.7	Heavy 82.9 Medium 7.2
0930-1200	Heavy 22.3 Medium 67.6	Heavy 49.2 Medium 39.8
1200-1400	Heavy 32.4 Medium 55.4	Heavy 19.3 Medium 61.9
1400-1630	Heavy 25.0 Medium 59.5	Heavy 30.4 Medium 52.5
1630-1830	Heavy 92.6 Medium 5.4	Heavy 83.4 Medium 5.5
1830-2000	Heavy 28.4 Medium 60.1	Heavy 14.9 Medium 59.1
After 2000	Medium 50.7 Light 43.9	Medium 21.0 Light 63.5

Note
[1] Sample number refers to number of respondents.
Results refer to question 19 (Form A) and question 12 (Form C) "description of traffic flow". (All questionnaire forms appear in Appendix 1).

Descriptions of traffic flow at certain times of the day have a strong relationship with how conditions for pedestrians and safety levels on the case study streets are viewed. In the survey of residents on Bruntsfield Place, conditions for pedestrians in Bruntsfield Place were found to be linked with descriptions of traffic flow at 0930-1200, 1830-2000, and after 2000 (table 5.18). Bad conditions for pedestrians are associated with heavy flows, and to a lesser extent, with light and medium traffic flows. For example, between 0930-1200, 65.6% who stated that traffic flow was heavy also thought that conditions were bad for pedestrians, while a smaller but nonetheless substantial minority, 35.5%, felt conditions were also bad for pedestrians when traffic flows were lighter (table 5.18).

Table 5.18 Conditions for Pedestrians in Bruntsfield Place and Traffic Conditions by Time Period, Residents' Survey, Bruntsfield Place.

Time Period	Perceived Traffic Level	Sample Number[1]		Very Bad	Bad	Good Nor Bad	Good
0930-1200	Light + Medium	104	%	8.6	26.9	51.0	13.5
0930-1200	Heavy	32	%	28.1	37.5	28.1	6.3
1830-2000	Light + Medium	101	%	6.9	30.7	49.5	12.8
1830-2000	Heavy	42	%	26.2	26.2	38.1	9.5
After 2000	Light	65	%	9.2	30.8	43.1	16.9
After 2000	Medium	74	%	13.5	28.4	50.0	8.1

Note
[1] Sample number refers to number of respondents.
Results refer to question 12 "conditions for pedestrians on Bruntsfield Place" and question 19 "description of traffic flow" (Form A, Appendix 1).

The Raeburn Place survey also revealed that residents' descriptions of traffic flow for certain time periods is strongly associated with perceptions of bad conditions for pedestrians, in terms of certain features of the street (table 5.19). Bad conditions for pedestrians were associated with periods during which traffic flows were heavy, although the proportion regarding conditions as bad is high even for those indicating relatively high/medium traffic flows.

Table 5.19 Description of Traffic Flow and Bad Conditions of Street Features, Residents' Survey, Raeburn Place.

Street Feature	Time Period	Sample Number[1]		Respondents Stating Heavy Traffic Flow and % also Stating Bad Conditions	Sample Number[1]		Respondents Stating Light/ Medium Traffic Flow and % also Stating Bad Conditions
Parked Cars	1200-1400 1400-1630	34 55	% %	44.1 25.5	124 111	% %	31.5 37.8
Traffic Level	0930-1200 1200-1400 1400-1630 1830-2000 After 2000	88 34 53 26 41	% % % % %	53.4 44.1 45.3 34.6 39.0	73 122 111 130 113	% % % % %	37.0 36.7 45.9 50.0 48.7
Traffic Noise	1200-1400 1400-1630 After 2000	34 52 42	% % %	55.9 44.2 47.6	121 110 111	% % %	23.1 24.5 22.5
Traffic Fumes	1200-1400 1400-1630	32 51	% %	68.8 56.9	122 110	% %	31.1 32.7
Traffic Speed	0930-1200	89	%	53.9	73	%	41.1

Note
[1] Sample number refers to number of respondents.
Results refer to question 12 "description of traffic flow" and question 9 "street feature/condition" (Form C, Appendix 1).

5.4.4 Perceptions and effect of traffic speed

Perceived traffic speed

69.9% of residents and 51.1% of respondents in the on-street survey in Bruntsfield Place, and 68.3% of residents in Raeburn Place, stated that they thought traffic speeds attained were under 30 m.p.h.. It should be noted however, that this may be affected by the fact that respondents usually know that the speed limits in these streets are 30 m.p.h., and therefore assume that it is unlikely that speeds will be over this. Despite this, a large proportion thought that speeds were 31-35 m.p.h.: 27.7% on Raeburn Place and 32.4% on Bruntsfield Place in the on-street survey compared to 17.1% in the residents survey of

Bruntsfield Place. A much lower proportion of respondents on Raeburn Place than on Bruntsfield Place thought that traffic travelled at over 35 m.p.h. (table 5.20).

Table 5.20 Perceived Traffic Speed Levels in Raeburn Place and Bruntsfield Place.

Perceived Traffic Speed (MPH) *Sample Number*[1]	**Bruntsfield Place Residents** *140* %	**Bruntsfield Place On-Street** *170* %	**Raeburn Place Residents** *177* %
0-15	**2.1**	**0.5**	**1.1**
16-20	**12.1**	**5.8**	**5.0**
21-25	**23.6**	**12.4**	**26.6**
26-30	**32.1**	**32.4**	**35.6**
31-35	**17.1**	**32.4**	**27.7**
35+	**12.9**	**16.5**	**4.0**

Note
[1] Sample number refers to number of respondents.
Results refer to "stated traffic speed" question 21 (Form A), question 15 (Form B) and question 13 (Form C). (All questionnaire forms appear in Appendix 1).

For both streets, a significant relationship was found between car availability and the speed at which residents thought traffic travelled at most of the time. Those residents who did not have a car available to them and who probably spend more time as a pedestrian, felt that traffic travelled at greater speeds than those who stated that they did have a car available to them. In the Bruntsfield Place survey, 39.5% of respondents who had no car available thought that traffic travelled at speeds over 30 m.p.h., compared to 14.5% who did have a car available. Similarly, in Raeburn Place, 34.4% of respondents who had no car available thought that traffic travelled at over 30 m.p.h., compared to 25.5% who did have a car available (table 5.21).

Table 5.21 Perceived Traffic Speed Levels and Car Availability, Residents' Surveys, Raeburn Place and Bruntsfield Place.

	Bruntsfield Place		Raeburn Place	
Perceived Traffic Speed (MPH) *Sample Number*[1]	**Car Available** *55* %	**No Car Available** *81* %	**Car Available** *55* %	**No Car Available** *122* %
0-25	**52.7**	**29.6**	**47.3**	**26.2**
26-30	**32.7**	**30.9**	**27.3**	**39.3**
Over 30	**14.5**	**39.5**	**25.5**	**34.4**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 21 "stated traffic speed" and question 7 "car availability" (Form A), and question 13 "stated traffic speed" and question 5 "car availability" (Form C). (All questionnaire forms appear in Appendix 1).

Effect of traffic speed levels

43.9% (65 cases) of residents and 34.3% of respondents in the on-street survey stated that traffic speed had some effect on them as pedestrians in Bruntsfield Place. However, none of the respondents in either survey stated what form this effect took in the space provided on the questionnaire form. In the Raeburn Place survey, a lower proportion (23.8%) stated that traffic speed had some effect on them as pedestrians. Of these 23.8%, 21 cases from 43 stated what the effects were in the space provided on the questionnaire form (table 5.22). Most respondents stated that excessive traffic speeds made it hard to cross the road.

Table 5.22 Stated Effect of Traffic Speed, Residents' Survey, Raeburn Place.

Stated Effect of Traffic Speed	Number of respondents (cases)
Excessive Speed	2
Move to Crossing Facility	2
Difficult to Cross Road	15
Need to be Accompanied	2

Note
Results refer to question 14 (Form C, Appendix 1).

A significant association was found between the effect of traffic speed on residents and the frequency of walking trips made along each street. On both streets, for all trip frequencies, except those making over 2 trips a day on Bruntsfield Place, a larger proportion of residents stated that traffic speed had no effect on them (table 5.23a-b). This pattern is also reflected in the data which indicates that a higher proportion in each age group, on Raeburn Place, stated that traffic speed had no effect on them (table 5.24).

Table 5.23a Trip frequency and the Effect of Traffic Speed, Residents' Survey, Raeburn Place.

Trip Frequency	Sample Number[1]		Stating Some Effect	Stating No Effect
Up to 2 a Week	29	%	44.8	55.2
3-5 a Week	41	%	22.0	78.0
1 a Day	41	%	4.9	95.1
2 a Day	38	%	21.1	78.9
Over 2 a Day	28	%	39.3	60.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 14 "effect of traffic speed" and question 1 "trip frequency" (Form C, Appendix 1).

Table 5.23b Trip Frequency and the Effect of Traffic Speed, Residents' Survey, Bruntsfield Place.

Trip Frequency	Sample Number[1]		Stating Some Effect	Stating No Effect
Up to 2 a Week	1	%	100.0	0.0
3-5 a Week	15	%	40.0	60.0
1 a Day	34	%	41.2	58.8
2 a Day	51	%	33.3	66.7
Over 2 a Day	42	%	64.3	35.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 22 "effect of traffic speed" and question 3 "trip frequency" (Form A, Appendix 1).

Table 5.24 Effect of Traffic Speed and Age, Residents' Survey, Raeburn Place.

Age	Sample Number[1]		Some Effect	No Effect
0-18	19	%	15.8	84.2
19-24	40	%	12.5	87.5
25-65	73	%	20.5	79.5
Over 65	45	%	44.4	55.6

Note
[1] Sample number refers to number of respondents.
Results refer to question 14 "effect of traffic speed" and question 25 "age" (Form C, Appendix 1).

Although speeds are associated with the creation of adverse conditions for pedestrians, it is not clear at what level perceived speeds affect pedestrian mobility. Traffic speed was found to have an effect on attitudes towards conditions for pedestrians in Edinburgh generally, and on both case study streets. The tendency was for respondents who stated that traffic speed had some effect on them as pedestrians to also state that conditions for pedestrians were bad in Edinburgh, Bruntsfield Place and Raeburn Place. For example, 55.9% and 70.6% of respondents on Raeburn Place and Bruntsfield Place who stated that street conditions were very bad also felt that traffic speed had some effect, although larger proportions of respondents on Raeburn Place stated that their attitudes towards the conditions in the street did not neccesarily mean that traffic speed had any effect on them (table 5.25a-b). On Raeburn Place, 69.4% and 81.8% respectively stated that for bad and neither good nor bad conditions, traffic speed had no effect on them.

Table 5.25a Effect of Traffic Speed and Attitudes Towards Conditions for Pedestrians, Residents' Surveys, Raeburn Place.

Street Conditions	Sample Number[1]		Some Effect	No Effect
Very Bad	34	%	55.9	44.1
Bad	49	%	30.6	69.4
Neither Good Nor Bad	44	%	18.2	81.8
Good	50	%	2.0	98.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 14 "effect of traffic speed" and question 11 "conditions for pedestrians on Raeburn Place" (Form C, Appendix 1).

Table 5.25b Effect of Traffic Speed and Attitudes Towards Conditions for Pedestrians, Residents' Surveys, Bruntsfield Place.

Street Conditions	Sample Number[1]		Some Effect	No Effect
Very Bad	17	%	70.6	29.4
Bad	43	%	60.5	39.5
Neither Good Nor Bad	66	%	31.8	68.2
Good	17	%	29.4	70.6

Note
[1] Sample number refers to number of respondents.
Results refer to question 22 "effect of traffic speed and question 10 "conditions for pedestrians on Bruntsfield Place" (Form A, Appendix 1).

5.5 CROSSING THE ROAD IN RAEBURN PLACE AND BRUNTSFIELD PLACE

5.5.1 Residents' choice of crossing location

Results from both Bruntsfield Place and Raeburn Place, revealed that as traffic conditions become heavier there is a switch from informal to formal crossing locations. When traffic conditions were light in both streets, most residents stated that they crossed the road anywhere. Larger proportions of residents stating that they crossed at the Pelican crossings provided in each street as traffic conditions were seen to become heavier (table 5.26a-b).

Table 5.26a Choice of Crossing Location On Raeburn Place, Residents' Survey.

Perceived Traffic Level	Sample Number[1]		Raeburn Place % Crossing at a Pelican	Raeburn Place % Crossing Anywhere
Light	180	%	42.8	53.9
Medium	179	%	53.1	41.9
Heavy	179	%	74.9	21.0
Congested	180	%	34.4	58.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 19 "crossing location" (Form C, Appendix 1).

Table 5.26b Choice of Crossing Location On Bruntsfield Place, Residents' Survey.

Perceived Traffic Level	Sample Number[1]		Bruntsfield Place % Crossing at a Pelican Light	Bruntsfield Place % Crossing Anywhere
Light	146	%	15.1	54.1
Medium	147	%	25.9	33.3
Heavy	145	%	49.0	16.9
Congested	142	%	11.5	60.1

Note
[1] Sample number refers to number of respondents.
Results refer to question 20 "crossing location" (Form A, Appendix 1).

Analysis of the Raeburn Place questionnaire responses also revealed that the elderly (over 65) and young (under 18) strongly favour the use of Pelican crossings, as opposed to crossing anywhere in all traffic conditions (table 5.27). There is some switching, however, to Pelican crossings in all age groups as traffic conditions worsen. The high levels of usage of Pelican crossings by young and elderly pedestrians reflects behavioural findings that indicate pedestrians in these age groups are more susceptible to traffic barrier effects for all levels of traffic flow.

Behavioural analysis indicated that pedestrians aged under 18 and over 65 generally experience longer delays and favour larger acceptance gaps in which to cross. The extent of the switch to formal crossing facilities by the 18-24 and 25-65 age groups when traffic flow is heavy, is much greater, and related to associated increases in delay and the lack of suitable acceptance gaps in the traffic stream in which to cross.

When conditions become congested and the traffic is stationary in Raeburn Place, the proportions who are persuaded to cross anywhere, that is not at Pelican crossings, increases for all age groups (table 5.27).

Table 5.27 Crossing Location in Different Traffic Conditions and Age, Residents' Survey, Raeburn Place.

Age	Sample Number[1]		% Crossing at a Pelican	% Crossing Anywhere	Perceived Traffic Level
Under 18	19	%	78.9	21.1	Light
	18	%	88.9	11.1	Medium
	18	%	94.4	5.6	Heavy
	18	%	66.7	33.3	Congested
18-24	41	%	7.3	92.7	Light
	39	%	20.5	79.5	Medium
	38	%	55.3	44.7	Heavy
	39	%	2.6	97.4	Congested
25-65	71	%	28.2	71.8	Light
	71	%	46.5	53.5	Medium
	73	%	75.3	24.7	Heavy
	68	%	20.6	79.4	Congested
Over 65	43	%	90.7	9.3	Light
	42	%	90.5	9.5	Medium
	43	%	95.3	4.7	Heavy
	42	%	83.3	16.7	Congested

Note
[1] Sample number refers to number of respondents.
Results refer to question 19 "crossing location" and question 25 "age" (Form C, Appendix 1).

Raeburn Place data has also revealed significant relationships between frequency of walking trips and crossing location in all traffic conditions. During light conditions for all frequencies of walking trips, except up to 2 trips a week, a larger proportion of respondents stated that they crossed anywhere. However, as traffic conditions became progressively heavier the proportion of respondents crossing at Pelican crossings became greater for each trip frequency category than for those crossing anywhere and then declined again as conditions became congested (table 5.28).

Table 5.28 Crossings at Pelican Crossings in Different Traffic Conditions, According to Trip Frequency, Residents' Survey, Raeburn Place.

Perceived Traffic Flow						
Trip Frequency	**Sample Number[1]**		**Light**	**Medium**	**Heavy**	**Congested**
Up to 2 a Week	**28**	%	**82.1**	**89.3**	**96.4**	**63.0**
3-5 a Week	**42**	%	**38.5**	**55.0**	**75.0**	**36.8**
1 a Day	**42**	%	**26.2**	**31.7**	**76.2**	**20.0**
2 a Day	**40**	%	**40.5**	**55.6**	**63.9**	**36.1**
Over 2 a Day	**28**	%	**46.4**	**60.0**	**84.6**	**38.5**

Note
[1] Sample number refers to number of respondents.
Results refer to question 19 "crossing location" and question 1 "trip frequency" (Form C, Appendix 1).

The large proportion of respondents who stated that they make up to 2 trips a week and who use a Pelican crossing for all traffic conditions, may be due to the fact that 65.5% of these respondents were aged over 65 and therefore may seek the extra security offered by a Pelican crossing when crossing the road. Those pedestrians who make over 2 trips a day, for all traffic conditions, also appear to use Pelican crossings to a greater extent by comparison to other trip categories. This may be accounted for by the fact that of those pedestrians, 17.9% were aged under 18 and 25% were aged over 65.

Choice of crossing location was also affected by how respondents felt the conditions of certain street features impinged on the pedestrian's environment. Respondents, who perceived conditions of street features to be bad for pedestrians, also stated in higher proportions for all levels of traffic condition that they crossed at a Pelican crossing (table 5.29). Adverse perceptions of traffic conditions clearly influenced the choice of crossing location. Those respondents who found conditions neither good nor bad tended to state that they crossed anywhere, except when traffic conditions were heavy. 81.6% of respondents who stated that conditions created by parked cars were neither good nor bad also stated that they crossed anywhere in light traffic conditions. Table 5.29 shows similar patterns for all the street features identified in the questionnaire survey of Raeburn Place, under differing traffic conditions.

Similarly, respondents who stated that they were affected by traffic speed, were discouraged from undertaking activities, and took different routes when walking (or would, if one were available) as a result of traffic conditions in Raeburn Place, also seemed to favour more secure crossing locations at Pelican crossings except when conditions were congested.

Table 5.29 Conditions of Street Features and Choice of Crossing Location, Residents' Survey, Raeburn Place.

Street Feature/ Condition	% Stating Conditions Bad and Crossing at Pelican Crossing[1]	% Stating Conditions Neither Good nor Bad and Crossing Anywhere[2]	Perceived Traffic Level
Parked Cars	58.3	81.6	Light
Sample Number	71.9	70.3	Medium
[1]60 [2]77	86.0	38.2	Heavy
	44.8	81.1	Congested
Traffic Level	46.7	73.2	Light
Sample Number	56.6	56.4	Medium
[1]77 [2]42	84.2	35.7	Heavy
	34.2	74.4	Congested
Pavement Obstuct.	68.1	72.1	Light
Sample Number	83.1	60.9	Medium
[1]76 [2]69	90.0	31.8	Heavy
	55.2	77.3	Congested
Traffic Noise	57.1	57.1	Light
Sample Number	73.2	44.1	Medium
[1]60 [2]72	96.2	22.5	Heavy
	49.0	66.7	Congested
Load	61.3	73.7	Light
/Unload Vehicles	74.4	61.6	Medium
Sample Number	89.9	35.6	Heavy
[1]84 [2]77	48.1	76.7	Congested
Traffic Fumes	60.9	58.6	Light
Sample Number	76.5	50.9	Medium
[1]74 [2]59	89.6	22.4	Heavy
	50.0	69.6	Congested
Traffic Speed	62.4	71.4	Light
Sample Number	73.5	63.0	Medium
[1]90 [2]56	86.6	27.3	Heavy
	49.4	75.5	Congested

Note
Results refer to question 19 "crossing location" and question 9 "street feature/condition" (Form C, Appendix 1).
Sample numbers indicated [1] refer to base sample figures for % stating conditions are bad and crossing at a Pelican crossing and [2] for % stating conditions neither good nor bad and crossing anywhere.

5.5.2 Levels of perceived safety and difficulty experienced when crossing the road

35.5% of respondents in Raeburn Place stated that they felt some degree of unsafety (16.6% unsafe and 18.9% very unsafe) when crossing Raeburn Place. By comparison, 37.7% stated that they felt conditions for pedestrians were safe and 26.8% stated that they felt neither safe nor unsafe. However, 53.7% of respondents stated that some degree of difficulty was experienced when crossing Raeburn Place, while only 26% found that crossing was easy or very easy (table 5.30).

Table 5.30 Perceived Safety and Crossing Difficulty Levels, Residents' Survey, Raeburn Place.

Perceived Safety Level *Sample Number*[1]	% of Respondents *175*	Perceived Crossing Difficulty Level	% of Respondents *177*
Very Safe	8.0	Very Easy	6.8
Safe	29.7	Easy	19.2
Neither Safe or Unsafe	26.8	Neither Easy or Difficult	20.3
Unsafe	16.6	Difficult	23.7
Very Unsafe	18.9	Very Difficult	30.0

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 18 "perceived safety and crossing difficulty" (Form C, Appendix 1).

A substantial proportion of respondents aged over 65 felt very unsafe (39%) and found crossing very difficult (58.5%) in Raeburn Place. 31.6% of those aged under 18 found conditions unsafe or very unsafe but a much higher proportion found crossing difficult or very difficult (68.4%). A relatively high proportion of those in the 25-65 and 19-24 age groups found conditions safe or very safe, 46.6 and 58.5% respectively, and relatively easy to cross: 26.8% aged 19-24 and 34.2% of those aged 25-65 found crossing easy or very easy. Nonetheless, 23.3% of those aged 25-65 and 29.3% aged 19-24 stated that they found crossing the road difficult (table 5.31 and 5.32). Higher levels of crossing difficulty and lower levels of perceived safety were clearly experienced by those in the under 18 and over 65 age groups. This would account for the relatively high levels of usage of pedestrian crossing facilities associated with these age groups. These findings were substantiated by those of the video study which clearly indicated that pedestrians in the under 18 and over 65 age groups experience the traffic barrier effect to a greater extent.

Table 5.31 Perceived Safety Levels by Age, Residents' Survey, Raeburn Place.

	Age Group			
Perceived Safety Level	**0-18**	**19-24**	**25-65**	**Over 65**
Sample Number[1]	*19*	*41*	*73*	*41*
	%	%	%	%
Very Safe	**0.0**	**12.2**	**8.2**	**4.9**
Safe	**15.8**	**46.3**	**38.4**	**4.9**
Neither Safe nor Unsafe	**52.6**	**26.8**	**20.5**	**26.8**
Unsafe	**15.8**	**7.3**	**17.8**	**24.4**
Very Unsafe	**15.8**	**7.3**	**15.1**	**39.0**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 18 "perceived safety" and question 25 "age" (Form C, Appendix 1).

Table 5.32 Perceived Crossing Difficulty Levels by Age, Residents' Survey, Raeburn Place.

	Age Group			
Perceived Crossing Difficulty	**0-18**	**19-24**	**25-65**	**Over 65**
Sample Number[1]	*19* %	*41* %	*73* %	*41* %
Very Easy	**15.8**	**2.4**	**8.2**	**4.9**
Easy	**5.3**	**24.4**	**26.0**	**9.8**
Neither Easy nor Difficult	**10.5**	**34.1**	**20.5**	**12.2**
Difficult	**31.6**	**29.3**	**23.3**	**14.6**
Very Difficult	**36.8**	**9.8**	**21.9**	**58.5**

Note
[1] Sample number refers to number of respondents.
Results refer to question 18 "perceived crossing difficulty" and question 25 "age" (Form C, Appendix 1).

Unsafe conditions and experiences of crossing difficulty were also associated with perceived bad conditions in terms of certain identified street features, most of which were concerned with traffic-related environmental quality: parked cars, traffic level, traffic noise, traffic fumes, pavement obstructions and traffic speed. Table 5.33 highlights these links.

Similarly, substantial proportions of residents who stated that they crossed anywhere for all levels of traffic conditions, except in heavy traffic conditions, also stated that they felt conditions were safe and crossing Raeburn Place was easy (table 5.34). Residents who stated that they used Pelican crossings, however found the crossing situation difficult and unsafe in Raeburn Place (table 5.35).

Table 5.33 Perceived Crossing Difficulty and Unsafety according to Bad Conditions Associated with Street Features, Residents' Survey, Raeburn Place.

Street Feature/Condition	% Stating Unsafe and Bad Conditions in terms of Street Feature	% Stating Crossing Difficulty and Bad Conditions in Terms of Street Feature
Sample Number[1]	*29*	*41*
Parked Cars	55.2	46.3
Traffic Level	65.5	58.5
Pavement Obstructions	62.1	41.5
Traffic Noise	44.8	46.3
Loading/Unloading Vehicles	69.0	53.7
Traffic Fumes	65.5	39.0
Traffic Speed	62.1	61.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 18 "perceived safety and crossing difficulty" and question 9 "street feature/condition" (Form C, Appendix 1).

Table 5.34 Crossing Location and Perceived Safety, Residents' Survey, Raeburn Place.

Perceived Traffic Level	% Stating Unsafe and Crossing at Pelican Crossing	% Stating Safe and Crossing Anywhere
Sample Number[1]	*27*	*52*
Light	53.6	90.2
Medium	78.6	78.4
Heavy	74.1	36.5
Congested	44.4	90.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 18 "perceived safety" and question 19 "crossing location" (Form C, Appendix 1).

Table 5.35 Crossing Location and Perceived Crossing Difficulty, Residents' Survey, Raeburn Place.

Perceived Traffic Level	% Stating Crossing Difficult and Crossing at Pelican Crossing	% Crossing Stating Crossing Easy and Crossing Anywhere
Sample Number[1]	*41*	*34*
Light	46.3	75.8
Medium	65.0	68.8
Heavy	82.9	41.2
Congested	25.0	84.4

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 18 "perceived crossing difficulty" and question 19 "crossing location" (Form C, Appendix 1).

Findings indicate that perceived barrier effects: bad conditions in terms of traffic related environmental quality, high levels of crossing difficulty and low levels of safety, were all strongly associated with heavy traffic flows, resulting in the selection of secure crossing locations. Congested traffic conditions where traffic is stopped, however were perceived as conditions which were safer and easier to cross in to. A reduction in the proportions of those respondents stating that conditions were unsafe and crossing difficulties experienced was also found to occur in congested traffic conditions.

5.5.3 Crossing from behind parked vehicles

66.1% (119 cases) of residents in the Raeburn Place survey stated that they crossed from behind parked vehicles. 61.5% of these respondents stated that it did not increase feelings of security or safety and 66.4% stated that it also made it harder to see oncoming traffic. Despite this, 79% felt that crossing from behind parked vehicles made it easier to cross into gaps in the oncoming traffic stream (table 5.36). Behavioural analysis has indicated that crossing from behind a parked vehicle enabled pedestrians to select shorter acceptance gaps in the nearside carriageway.

Table 5.36 Effects of Crossing from Behind Parked Vehicles, Residents' Survey, Raeburn Place.

Response *Sample Number*[1]	**Increase Feelings of Security and Safety** *119* %	**Easier to Cross into Gaps in Traffic** *119* %	**Harder to See Oncoming Traffic** *119* %
Yes	**10.3**	**79.0**	**66.4**
No	**61.5**	**18.5**	**31.1**
Don't Know	**28.2**	**2.5**	**2.5**

Note
[1] Sample number refers to number of respondents.
Results refer to question 20b (Form C, Appendix 1).

Residents who stated that they cross from behind parked vehicles were predominantly in the 18-24 and 25-65 age groups. 92.7% of respondents aged 18-24 and 82.4% aged 25-65 stated that they crossed from behind a parked vehicle, compared to only 26.3% of those aged under 18 and 32.6% of those aged over 65 (table 5.37). This would appear to indicate that those respondents aged under 18 and over 65 do not favour crossing from behind parked vehicles, although analysis of the video data indicated that there was no significant difference between age groups in terms of whether they crossed from behind a parked vehicle or not. This may, however, reflect the high levels of accompaniment evident in the video studies associated with these age groups, particularly in the case of the young, or the fact that higher parking levels may mean that they have little choice in whether they cross from behind a parked vehicle or not.

Table 5.37 Crossing from Behind Parked Vehicles and Age, Residents' Survey, Raeburn Place.

Age	Sample Number[1]		% Stating Crossing from Behind a Parked Vehicle	% Stating Not Crossing from Behind a Parked Vehicle
Under 18	19	%	26.3	73.7
19-24	41	%	92.7	7.3
25-65	74	%	82.4	17.6
Over 65	46	%	32.6	67.4

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 20a "crossing from behind a parked vehicle" and question 25 "age" (Form C, Appendix 1).

Further analysis revealed a significant difference between those respondents who stated that they crossed from behind a parked vehicle and those who stated that they did not, according to the frequency of walking trips made along Raeburn Place. For all trip frequencies, except for those making up to only 2 trips a week, a substantial proportion of respondents stated that they crossed from behind parked vehicles. Respondents who made journeys on foot more frequently stated that they found it easier to cross from behind a parked vehicle into gaps in the oncoming traffic stream (table 5.38). However, for those pedestrians making 2 trips a day and over, the proportion stating that crossing from behind a parked vehicle makes crossing into the gaps in the traffic stream easier reduces.

Table 5.38 Pedestrian Activity Level, Crossing from Behind a Parked Vehicle and Gaps in the Traffic, Residents' Survey, Raeburn Place.

Crossing from Behind Parked Vehicle					Easier to Cross into Gaps in Traffic Stream from Behind a Parked Vehicle			
Frequency of Walking Trips	Sample Number[1]		Yes (%)	No (%)	Sample Number[1]		Yes (%)	No (%)
Up to 2 a Week	29	%	34.5	65.5	10	%	80.0	20.0
3-5 a Week	42	%	66.7	33.3	27	%	74.1	25.9
1 a Day	42	%	78.6	21.4	33	%	93.9	6.1
2 a Day	39	%	71.8	28.2	25	%	88.0	12.0
Over 2 a Day	28	%	71.4	28.6	21	%	61.9	38.1

Note
[1] Sample number refers to number of respondents.
Results refer to question 20a "crossing from behind a parked vehicle" and question 20b "easier to cross into gaps" and question 1 "trip frequency" (Form C, Appendix 1).

48.3% of those residents crossing from behind a parked vehicle saw this as a very safe or safe activity, compared to 15.5% who did not cross from behind parked vehicles. This difference may be due to the impact of the different age groups in each sub-group. The group crossing from behind parked vehicles consisted predominantly of respondents from the 18-24 and the 25-65 age groups; groups which perceive safety levels as being relatively high (table 5.39).

Table 5.39 Crossing from Behind Parked Vehicles and Perceived Safety Levels, Residents' Survey, Raeburn Place.

			Perceived Safety Level				
Crossing from Behind a Parked Vehicle	Sample Number[1]		Very Safe (%)	Safe (%)	Neither Safe or Unsafe (%)	Unsafe (%)	Very Unsafe (%)
Yes	116	%	7.8	40.5	22.4	15.5	13.8
No	58	%	6.9	8.6	36.2	19.0	29.3

Note
[1] Sample number refers to number of respodents.
Results refer to question 20a "crossing from behind parked cars" and question 18 "perceived safety level" form C appendix 1.

Similarly, those who stated that they crossed from behind parked vehicles also stated that they experienced less crossing difficulties, 43.1% in this group stated that they found crossing very difficult or difficult, compared to 72.5% who stated that they did not cross from behind parked vehicles (table 5.40). Again these differences were largely a result of the differences between age groups. The video study, however, also indicated that pedestrians crossing from behind parked vehicles experience reductions in the traffic barrier. High proportions of crossings undertaken from behind parked vehicles were associated with heavy traffic flow levels, low speed levels and shorter acceptance gaps in the nearside carriageway.

Table 5.40 Crossing from Behind Parked Vehicles and Perceived Crossing Difficulty Levels, Residents' Survey, Raeburn Place.

Perceived Crossing Difficulty Level							
Crossing from Behind Parked Vehicles	Sample Number[1]		Very Easy (%)	Easy (%)	Neither Easy or Difficult (%)	Difficult (%)	Very Difficult (%)
Yes	116	%	7.8	24.1	25.0	22.4	20.7
No	58	%	5.2	10.3	12.1	25.9	46.6

Note
[1] Sample number refers to number of respondents.
Results refer to question 20a "crossing from behind a parked vehicle" and question 18 "perceived crossing difficulty" (Form C, Appendix 1).

5.5.4 Crossing destination

53% of respondents in the Raeburn Place survey stated that they crossed in order to get to the shops. 16.6% stated work and 13.8% stated that they crossed Raeburn Place to get to the bus stop (table 5.41). For all age groups, the shops in Raeburn Place are the most regularly stated crossing destination: 43.8% of those aged under 18; 47.4% of those aged 18-24; 64.2% of those aged 24-65; and 66.7% of those aged over 65. The bus stop is the second most frequent destination for those aged over 65 (33.3%). For those in the 18-24 and 25-65 age groups, work is the second most stated crossing destination (31.6% and 26.9% respectively) (table 5.42). These findings are in line with the expectation that the traffic barrier effect may be experienced to a larger extent in street sections where retail activity occurs. Video study findings also confirm that pedestrian activity levels are greater on pavements where more intensive retail landuses are located.

Table 5.41 Crossing Destination, Residents' Survey, Raeburn Place.

Crossing Destination *Sample Number*[1]	% of Respondents *178*
Bus Stop	13.8
Car	4.4
Shops	53.0
School/College	6.6
Work	16.6
Post Box	0.6
Personal	2.8

Note
[1] Sample number refers to number of respondents.
Results refer to question 21 "crossing destination" (Form C, Appendix 1).

Table 5.42 Crossing Destination and Age, Residents' Survey, Raeburn Place.

Destination *Sample Number*[1]	0-18 *16* %	19-24 *38* %	25-65 *67* %	Over 65 *42* %
Bus Stop	12.5	10.5	7.5	33.3
Shops	43.8	47.4	64.2	66.7
School/College	43.8	10.5	1.5	0.0
Work	0.0	31.6	26.9	0.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 21 "crossing destination" and question 25 "age" (Form C, Appendix 1).

5.6 DISCOURAGEMENT, DETERRENCE AND RESCHEDULING OF PEDESTRIAN ACTIVITY

5.6.1 Activities pedestrians are discouraged from undertaking

This section of analysis refers to the terms discouragement and deterrence. In the context of this study, discouragement, unlike deterrence, relates to access to activities such as shopping, work and meeting friends. These activities are associated with the ability to spend time in the street where factors, other than difficulties associated with road crossing activity, can have an impact, thereby placing constraints on pedestrian activity (see question 13 Form A, question 10 Form B and question 15 From C Appendix 1). Deterrence, on the other hand, in this study, explicitly refers to road crossing activity under different traffic flow conditions (see question 22 Form C Appendix 1). These definitions of discouragement and deterrence are consistent with each other, recognising the variation in behavioural response possible given certain street environment characteristics i.e. that a pedestrian may be discouraged from going out, where time spent in the street environment is an important consideration, but may not neccessarily be deterred from crossing the road on a route where destinations and activities may not be within the street section in question.

Even though many respondents encountered problems as pedestrians in Edinburgh and on the case study streets, only 13.2% (19 cases) in the residents' survey of Bruntsfield Place and a slightly larger proportion, 28.2% (51 cases) in Raeburn Place, felt that traffic conditions actually discouraged them from undertaking certain activities (either essential or optional). 23.5% (40 cases) of respondents in the on-street survey felt that traffic discouraged them from undertaking certain activities in the street. All 3 surveys revealed that most of those discouraged trips were in the morning (table 5.43 and 5.44). Most respondents who stated that they were discouraged said that more often than not it was a trip associated with shopping. In the survey of residents on Raeburn Place, 38 respondents stated that shopping was the activity they were discouraged from, compared to much smaller numbers for other activities: meeting friends (10); walking to or from work (11); personal business (9); walking to or from school or college (5); leisure (14). None of the Raeburn Place residents however, were able to state a time on the questionnaire at which discouragement occurred nor were they able to indicate the time of shifts in activities associated with walking, resulting from detrimental traffic conditions. Of those who stated that they were discouraged from undertaking activities at certain times, the largest proportion were in the over 65 age group (39.2%) (table 5.45).

Table 5.43 Times at which Discouragement Occurs (Cases), On-Street and Resident Surveys, Bruntsfield Place.

Time	Bruntsfield Place, Residents (Cases)	Bruntsfield Place, On-Street (Cases)
Morning	10	13
Afternoon	1	4
Evening	6	6
Not at All	2	4

Note
Results refer to question 13c (Form A) and question 10c (Form B). (All questionnaire forms appear in Appendix 1).

Table 5.44 Times at which Discouragement Occurs (Cases), Residents' Survey, Raeburn Place.

Time	Raeburn Place Residents (Cases)
Before 0830	11
0830-0929	19
0930-1129	18
1130-1359	10
1400-1529	9
1530-1700	18
After 2000	11

Note
Results refer to question 15c (Form C, Appendix 1).

Table 5.45 Activities Discouraged from by Traffic Conditions and Age, Residents' Survey, Raeburn Place.

Age	% Stating Discouraged	% Stating Not Discouraged
Sample Number[1]	*51*	*127*
0-18	11.8	10.2
19-24	13.7	26.8
25-65	35.3	44.1
Over 65	39.2	18.9

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 15a "discouraged" and question 25 "age" (Form C, Appendix 1).

In the Raeburn Place survey, those who that stated that they were discouraged at certain times also felt that conditions created by the street features, highlighted in the questionnaire, were bad for pedestrians (table 5.46). This is in line with findings reported earlier in the chapter.

Although discouragement was experienced under all traffic flow conditions, the proportion citing heavier traffic flows was larger, in every time period, for those stating that they were discouraged. The exception to this was the time period 0800-0930, where both those who stated that they were discouraged and those who were not, described the period as being dominated by heavy traffic flows (84.1% and 94.1% respectively) (table 5.47).

Table 5.46 Discouragement Resulting and Conditions for Pedestrians, Residents' Survey, Raeburn Place.

Street Feature/ Condition	Sample Number[1]		% Stating Discouraged and Conditions Very Bad	% Stating Discouraged and Conditions Bad	% Stating Discouraged and Conditions Neither Good Nor Bad
Parked Cars	51	%	39.2	43.1	17.6
Traffic Level	49	%	51.0	36.7	12.2
Pavement Obstructions	49	%	69.4	18.4	12.2
Traffic Noise	49	%	60.4	37.5	2.1
Traffic Fumes	48	%	0.0	66.7	33.3
Traffic Speed	48	%	0.0	74.5	21.6
Loading/ Unloading Vehicles	51	%	0.0	64.6	29.2

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "discouraged" and question 9 "street feature/condition" (Form C, Appendix 1).

Table 5.47 Description of Traffic Flow and Discouragement, Residents' Survey, Raeburn Place.

Time Period	Sample Number[1]		% Stating Discouraged and Heavy Traffic Flow	% Stating Discouraged and Light/ Medium Traffic Flow	Sample Number[1]		% Stating Not Discouraged and Heavy Traffic Flow	% Stating Not Discourageand Light/ Medium Traffic Flow
0800-0930	44	%	84.1	15.9	119	%	94.1	5.9
1200-1400	38	%	39.2	60.5	121	%	16.5	83.5
1400-1630	45	%	46.7	53.3	121	%	28.1	71.9
After 2000	41	%	43.9	56.1	115	%	20.9	79.1

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 15a "discouraged" and question 12 "description of traffic flow" (Form C, Appendix 1).

A strong relationship was found between whether a respondent stated that traffic conditions discouraged activities being undertaken and his/her description of Raeburn Place, in terms of perceived safety levels and crossing difficulty. 41.7% of residents who stated that they were discouraged from undertaking certain activities also found Raeburn Place very unsafe and 60% found Raeburn Place very difficult to cross (table 5.48 and 5.49). Those that stated that they were discouraged from undertaking certain activities also favoured the use of Pelican crossings, independent of whether traffic was stationary, heavy, light or medium (table 5.50). Discouragement was strongly associated with perceived high levels of crossing difficulty, low levels of safety, and the selection of more secure crossing locations.

Table 5.48 Perceived Safety Levels and Discouragement, Residents' Survey, Raeburn Place.

Perceived Safety Levels Raeburn Place *Sample Number[1]*	% Stating Discouraged *48*	% Stating not Discouraged *126*
Very Safe	0.0	11.1
Safe	8.3	38.1
Neither Safe nor Unsafe	22.9	28.6
Unsafe	27.1	12.7
Very Unsafe	41.7	9.5

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "discouraged" and question 18 "perceived safety" (Form C, Appendix 1).

Table 5.49 Perceived Crossing Difficulty and Discouragement, Residents' Survey, Raeburn Place.

Perceived Crossing Difficulty Raeburn Place *Sample Number[1]*	% Stating Discouraged *50*	% Stating Not Discouraged *126*
Very Easy	0.0	9.5
Easy	6.0	24.6
Neither Easy nor Difficult	8.0	25.4
Difficult	26.0	23.0
Very Difficult	60.0	17.5

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "discouraged" and question 18 "perceived crossing difficulty" (Form C, Appendix 1).

Table 5.50 Respondents Stating Discouragement and Crossing at Pelican Crossings or Anywhere for Different Traffic Conditions, Residents' Survey, Raeburn Place.

Perceived Traffic Level	Sample Number[1]		% Stating Discouraged and Crossing at Pelican	% Stating Discouraged and Crossing Anywhere
Light	49	%	71.4	28.6
Medium	46	%	82.6	17.4
Heavy	46	%	95.7	4.3
Congested	45	%	53.5	46.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "discouraged" and question 19 "crossing location" (Form C, Appendix 1).

82.3% (140 cases) of respondents in the Raeburn Place survey stated that they were not generally deterred from crossing Raeburn Place by the traffic conditions. Although 23.2% of residents stated that they were deterred from crossing when traffic flows were heavy, only 5.5% and 7.7% stated that they would be deterred from crossing when traffic flow levels were light and medium respectively. Similarly, 82.3% (149 cases) stated that traffic conditions did not generally result in them rescheduling their pedestrian trips to avoid crossing Raeburn Place. Only 14.9% stated that they would do so if flows were heavy.

Those who stated that they were most deterred from crossing Raeburn Place and stated that they did reschedule trips to avoid crossing in all traffic conditions were in the over 65 and 25-65 age groups, although the actual numbers involved were small (table 5.51).

Table 5.51 Deterrence and Rescheduling by Age, Residents' Survey, Raeburn Place.

Age	Sample Number[1]		% Stating Yes Deterred From Crossing	Sample Number[1]		% Stating Yes Reschedule Trips	Perceived Traffic Level
Under 18	28	%	3.6	23	%	4.3	Generally
	10	%	10.0	12	%	8.3	Light
	14	%	14.3	14	%	7.1	Medium
	42	%	16.7	27	%	18.5	Heavy
19-24	28	%	3.6	23	%	8.7	Generally
	10	%	0.0	12	%	0.0	Light
	14	%	14.3	14	%	7.1	Medium
	42	%	14.3	27	%	7.4	Heavy
25-65	28	%	35.7	23	%	30.4	Generally
	10	%	40.0	12	%	33.3	Light
	14	%	50.0	14	%	50.0	Medium
	42	%	33.3	27	%	29.6	Heavy
Over 65	28	%	57.1	23	%	56.5	Generally
	10	%	50.0	12	%	58.3	Light
	14	%	21.4	14	%	35.7	Medium
	42	%	35.7	27	%	44.4	Heavy

Note
[1] Sample number refers to number of respondents.
Results refer to question 22 "deterred", question 23 "reschedule" and question 25 "age" (Form C, Appendix 1).

Although residents did appear to be discouraged from undertaking activities due to the traffic conditions, they were generally not deterred from crossing the road: 65.1% of residents who stated that they were discouraged to undertake activities also stated that they were not deterred from crossing the road. A similar picture emerged from the responses of those who stated that they were discouraged from undertaking certain activities and who were not deterred from crossing the road when traffic conditions were light (86.1%) and medium (82.4%). This pattern, however, changed when traffic flows were heavy with 59% stating that they were discouraged from undertaking certain activities and are deterred from crossing in Raeburn Place. Further analysis also revealed that residents, as pedestrians, although discouraged from undertaking certain activities as pedestrians, were not prone to reschedule pedestrian trips to avoid crossing Raeburn Place, even when traffic flows were heavy. 62.2% stated that although they were discouraged from undertaking certain activities, they would not reschedule their pedestrian trips to avoid crossing Raeburn Place (table 5.52a-b). Traffic barrier effects resulting from heavy traffic flows created changes in trip-making behaviour. For lower perceived levels of flow, although discouraged, smaller proportions of pedestrians were actually deterred from crossing the road, or rescheduled their trips.

Table 5.52a Respondents Discouraged from Undertaking Certain Activities and Deterred from Crossing the Road by Traffic Condition, Residents' Survey, Raeburn Place.

Perceived Traffic Level	Sample Number[1]		% Stating Discouraged and Deterred	% Stating Discouraged and Not Deterred
Generally	43	%	34.9	65.1
Light	36	%	13.9	86.1
Medium	34	%	17.6	82.4
Heavy	39	%	59.0	41.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "discouraged" and question 22 "deterred" (Form C, Appendix 1).

Table 5.52b Respondents Discouraged from Undertaking Certain Activities and Rescheduling Trips by Traffic Condition, Residents' Survey, Raeburn Place.

Perceived Traffic Level	Sample Number[1]		% Stating Discouraged and Reschedule Trips	% Stating Discouraged and Don't Reschedule Trips
Generally	43	%	20.0	80.0
Light	36	%	16.7	83.3
Medium	34	%	24.2	75.8
Heavy	39	%	37.8	62.2

Note
[1] Sample number refers to number of pedestrians.
Results refer to question 15a "discouraged" and question 23 "reschedule" (Form C, Appendix 1).

5.6.2 Pedestrians encouraged to take a different route

In the Bruntsfield Place surveys, 22.6% of residents and 15.3% of respondents in the on-street survey stated that they were encouraged to take a different route when walking, as a result of the traffic conditions in Bruntsfield Place. In addition to this, 14.4% of residents and 12.9% of those surveyed on-street stated that no alternative route was available at all. This implies that if an alternative route were available, they would take that alternative route when out walking as a result of the traffic conditions. For Raeburn Place, a lower proportion, only 10.0%, stated that they ever took a different route when walking in Raeburn Place as a result of traffic conditions, although 43.3% stated that no alternative route was available. This would appear to conform with the difference in layouts between the two case study streets. On Bruntsfield Place, there are more alternative routes available than on Raeburn Place. The largest proportion of respondents however, specifically stated that they did not take a different route as a result of traffic conditions (table 5.53).

Table 5.53 Changes of Pedestrian Route, Bruntsfield Place and Raeburn Place.

Different Route Taken *Sample Number*[1]	Bruntsfield Place Residents *146* %	Bruntsfield Place On-Street *170* %	Raeburn Place Residents *180* %
Yes	22.3	15.3	9.9
No	62.2	71.8	46.4
No Alternative Available	14.2	12.9	43.1

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a (Form A), question 11a (Form B) and question 16a (Form C). (All questionnaires referred to are in Appendix 1).

Further analysis revealed that those respondents who did take different routes or would have done so if one were available, felt that conditions for pedestrians were bad or very bad in both Bruntsfield Place and Raeburn Place. 60.6% of those who stated that they did take a different route when walking, also found traffic conditions in Bruntsfield Place bad or very bad. Similarly, 76.2% of those who stated that no alternative route was available, also stated that conditions were bad or very bad for pedestrians in Bruntsfield Place (table 5.54). On Raeburn Place, 83.3% who stated that they did take a different route as a result of traffic conditions also found conditions for pedestrians in Raeburn Place bad or very bad, while 62.8% of those who stated that no alternative route was available, also felt that conditions were bad or very bad for pedestrians (table 5.55). Unfavourable levels of parked cars, traffic, traffic noise, traffic fumes, traffic speeds and poor pavement conditions were also strongly associated with encouraging residents into thinking of a different route when walking, even though no alternative route was available (table 5.56). This is especially so in the case of perceived conditions relating to traffic levels, traffic speed, and pavement obstructions; all key features of any pedestrian environment.

Table 5.54 Conditions for Pedestrians on Bruntsfield Place and if Alternative Route Taken, Residents' Survey, Bruntsfield Place.

Conditions *Sample Number*[1]	Take an Alternative Route *33* %	Don't Take Alternative Route *90* %	No Alternative Route Available *21* %
Very Bad	21.2	5.6	23.8
Bad	39.4	22.2	52.4
Neither Good Nor Bad	27.3	57.8	23.8
Good	12.1	14.4	0.0

Note
[1] Sample number refers to number of respondents.
Results refer to question 15a "route change" and question 12 "conditions for pedestrian in Bruntsfield Place" (Form A, Appendix 1).

Table 5.55 Conditions for Pedestrians on Raeburn Place and if Alternative Route Taken, Residents' Survey, Raeburn Place.

Conditions *Sample Number*[1]	Take an Alternative Route *18* %	Don't Take and Alternative Route *84* %	No Alternative Route Available *78* %
Very Bad	44.4	8.3	26.9
Bad	38.9	16.7	35.9
Neither Good Nor Bad	16.7	31.0	20.5
Good	0.0	44.0	16.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 16a "route change" and question 11 "conditions for pedestrians in Raeburn Place" (Form C, Appendix 1).

Table 5.56 Conditions of Street Features and No Alternative Route Available, Residents' Survey, Raeburn Place.

Street Feature/ Condition	Sample Number[1]		% of Respondents Stating No Alternative Route Available and Street Feature Conditions Bad	% of Respondents Stating No Alternative Route Available and Street Feature Conditions Neither Good Nor Bad
Parked Cars	77	%	39.0	37.7
Traffic Level	77	%	66.2	13.0
Pavement Obstructions	78	%	52.6	35.9
Traffic Noise	77	%	32.5	46.8
Traffic Fumes	78	%	41.0	42.3
Traffic Speed	78	%	61.5	34.6

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 16a "route change" and question 9 "street feature/condition" (Form C, Appendix 1).

In addition, residents who tended to describe traffic flows as heavy for certain times of day also indicated, in the questionnaire, that as a result of the traffic conditions they would take an alternative route when walking. Analysis revealed that this interpretation did not hold for descriptions of traffic flow between 1200-1400 and after 2000 in the evening. These two periods were associated with relatively lighter flows; flows which nonetheless would still encourage residents to take an alternative route if this was available. This may be due to the fact that traffic speeds are perceived to be higher during these time periods (table 5.57).

Table 5.57 Description of Traffic Conditions and Residents Stating They Would Take an Alternative Route, Residents' Survey, Raeburn Place.

Time	Sample Number[1]		Description of Traffic Flow and % of Respondents Stating Alternative Route
0800-0930	72	%	Heavy 97.3
0930-1200	50	%	Heavy 66.7
1200-1400	50	%	Light + Medium 70.4
1630-1830	71	%	Heavy 97.3
After 2000	50	%	Light 67.6

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 16a "route change" and question 12 "description of traffic flow" (Form C, Appendix 1).

Of those residents on Bruntsfield Place, who took a different route when walking (36 cases), most stated that they would do so in the morning (38.9%) and in the evening (19.4%). Only 14 respondents in the Raeburn Place survey stated the times at which a different route tended to be taken: 3 before 0830; 5 between 0830 and 0929; 4 between 0930 and 1129; 3 between 1130 and 1359; 2 between 1400 and 1529; 5 between 1530 and 1700; 5 after 1700. 3 respondents stated that the time at which a different route tended to be taken varied. As with those who stated that they were discouraged from undertaking activities due to traffic conditions, it would seem that the morning and evening periods are especially associated with re-routeing.

Levels of safety and crossing difficulty in Raeburn Place were also associated with the decision to take an alternative route if one was available. 76.4% of respondents in the Raeburn Place survey, who stated that would take a different route when walking due to traffic conditions, also stated that conditions were very unsafe or unsafe, while 38.7% of those who stated that they would take an alternative route if one was available felt that conditions were unsafe or very unsafe (figure 5.58). In the case of levels of crossing difficulty experienced in Raeburn Place, 83.3% who stated that they would take an alternative route, and 67.1% who stated that they would take an alternative route if one were available, found crossing Raeburn Place very difficult or difficult (table 5.59).

Table 5.58 Route Choice and Safety Levels, Residents' Survey, Raeburn Place.

Perceived Safety Level							
Route Choice	Sample Number[1]		Very Safe	Safe	Neither Safe or Unsafe	Unsafe	Very Unsafe
Yes	17	%	0.0	0.0	23.5	17.6	58.8
No	82	%	15.9	41.5	19.5	13.4	9.8
No Alternative Available	75	%	1.3	24.0	36.0	20.0	18.7

Note
[1] Sample number refers to number of respondents.
Results refer to question 16a "route change" and question 18 "perceived safety" (Form C, Appendix 1).

Table 5.59 Route Choice and Levels of Crossing Difficulty, Residents' Survey, Raeburn Place.

Route Choice	Sample Number[1]		Very Easy	Easy	Neither Easy or Difficult	Difficult	Very Difficult
Yes	18	%	0.0	11.1	5.6	11.1	72.2
No	82	%	14.6	25.6	25.6	22.2	12.2
No Alternative Available	76	%	0.0	14.5	18.4	28.9	38.2

Note
[1] Sample number refers to number of respondents.
Results refer to question 16a "route change" and question 18 "perceived crossing difficulty" (Form C, Appendix 1).

However, for all traffic conditions, even though respondents had stated that they would take an alternative route, or an alternative route if one were available, respondents were not deterred from crossing Raeburn Place nor would they reschedule their walking trips to avoid crossing Raeburn Place (table 5.60 and table 5.61).

Table 5.60 Route Choice and the Impact of Deterrence (from Crossing the Road) under Different Traffic Conditions on Pedestrian Trips, Residents' Survey, Raeburn Place.

Perceived Traffic Level *Sample Number*[1]	% Change Route and Not Deterred *18*	% Not Change Route and Not Deterred *84*	% Change Route but No Alternative Available and Not Deterred *78*
Generally	50.0	87.5	86.3
Light	75.0	95.7	94.2
Medium	63.6	97.1	88.2
Heavy	50.0	84.3	64.8

Note
[1] Sample number refers to number of respondents.
Results refer to question 16a "route change" and question 22 "deterred" (Form C, Appendix 1).

Table 5.61 Route Choice and Traffic Conditions and the Rescheduling of Pedestrian Trips, Residents' Survey, Raeburn Place.

Perceived Traffic Level *Sample Number*[1]	% Change Route and Not Reschedule *18*	% Not Change Route and Not Reschedule *84*	% Change Route but No Alternative Available *78*
Generally	60.0	93.8	85.5
Light	81.8	95.7	89.7
Medium	70.0	97.0	86.6
Heavy	50.0	91.4	76.5

Note
[1] Sample number refers to number of respondents.
Results refer to question 16a "route change" and question 22 "reschedule" (Form C, Appendix 1).
Sample numbers refer to base sample sizes.

5.6.3 Modal change resulting from traffic conditions

Some respondents stated that traffic conditions had encouraged them to use another mode of transport: 23.1% on Bruntsfield Place and 30.9% on Raeburn Place, in both resident surveys. In the on-street survey of pedestrians on Bruntsfield Place, a higher proportion of 32.9% was recorded (table 5.62).

Table 5.62 Modal Change resulting from Traffic Conditions, Bruntsfield Place and Raeburn Place.

Encouraged to Change Modes *Sample Number*[1]	Bruntsfield Place Residents *143* *%*	Bruntsfield Place On-Street *170* *%*	Raeburn Place Residents *175* *%*
Yes	22.3	32.9	29.8
No	74.3	67.1	66.9

Note
[1] Sample number refers to number of respondents.
Results refer to question 17a (Form A), question 12a (Form B) and question 17a (Form C).
(All questionnaire forms appear in Appendix 1).

In all surveys, a substantial proportion of respondents who stated that traffic conditions encouraged them to change modes, also stated that they were encouraged to switch to using the bus. Much smaller proportions of respondents were encouraged to switch to cars and taxis. For Raeburn Place, a larger proportion than in either of the Bruntsfield Place surveys, stated that they were encouraged to use cars: 27.1% compared to 9.7% of residents on Bruntsfield Place and 12.3% of on-street pedestrians in Bruntsfield Place (table 5.63). This result does not reflect the lower level of car availability recorded amongst respondents in the Raeburn Place survey (p221-222).

Table 5.63 Mode Encouraged to Switch to due to Traffic Conditions, Bruntsfield Place and Raeburn Place.

Mode Encouraged to Switch to	**Bruntsfield Place Residents**	**Bruntsfield Place On-Street**	**Raeburn Place Residents**
Sample Number[1]	*31* %	*57* %	*59* %
Bus	**71.0**	**64.9**	**52.5**
Car	**9.7**	**12.3**	**27.1**
Taxi	**6.5**	**14.0**	**15.3**
Bicycle	**9.7**	**7.0**	**5.1**
Motorcycle	**3.2**	**1.8**	**0.0**

Note
[1] **Sample number refers to number of respondents.**
Results refer to question 17b (Form A), question 12b (Form B) and question 17b (Form C).
(All questionnaire forms appear in Appendix 1).

Poor conditions for pedestrians in Edinburgh generally, resulting from adverse traffic conditions clearly encourage residents to switch from walking to another mode of transport. 24.2% of those who stated that they were encouraged to use another mode of transport also felt that conditions were very bad for pedestrians in Edinburgh generally (table 5.64).

Table 5.64 Modal Change Resulting from Traffic Conditions and Conditions for Pedestrians in Edinburgh Generally, Residents' Survey, Bruntsfield Place.

Conditions for Pedestrians in Edinburgh						
Encouraged to Change Modes	**Sample Number[1]**		**Very Bad (%)**	**Bad (%)**	**Neither Good or Bad (%)**	**Good (%)**
Yes	**33**	**%**	**24.2**	**21.2**	**42.2**	**12.1**
No	**110**	**%**	**7.3**	**22.7**	**50.0**	**20.0**

Note
[1] Sample number refers to number of respondents.
Results refer to question 17a "modal change" and question 11 "conditions for pedestrians in Edinburgh" (Form A, Appendix 1).

The survey of residents on Raeburn Place revealed that respondents who had doubts over their safety as a pedestrian in the street and who found it difficult to cross, were also encouraged to use another mode of transport (table 5.65 and table 5.66). 30.2% of respondents who stated that they switched to another mode of transport did so because they found conditions unsafe or very unsafe, while 66% felt crossing was difficult or very difficult. However, 38.1% who were not encouraged to switch to another mode of transport also felt conditions were unsafe or very unsafe, while 49.1% of respondents who did not switch to another mode of transport felt crossing was difficult or very difficult. Clearly then, residents who find Raeburn unsafe and difficult to cross are not necessarily encouraged to change modes. This may reflect constraints in terms of activities undertaken locally, and other destinations or activities, which are not well served by other modes of transport.

Table 5.65 Modal Change and Perceived Safety Conditions, Residents' Survey, Raeburn Place.

Perceived Safety Level							
Encouraged to Change Mode	Sample Number[1]		Very Safe (%)	Safe (%)	Neither Safe or Unsafe (%)	Unsafe (%)	Very Unsafe (%)
Yes	33	%	1.9	24.3	43.4	15.1	15.1
No	118	%	10.2	33.1	18.6	17.8	20.3

Note
[1] Sample number refers to number of respondents.
Results refer to question 17a "modal change" and question 18 "perceived safety level" (Form C, Appendix 1).

Table 5.66 Modal Change and Crossing Difficulty, Residents' Survey, Raeburn Place.

Perceived Crossing Difficulty							
Encouraged to Change Modes	Sample Number[1]		Very Easy (%)	Easy (%)	Neither Easy of Difficult (%)	Difficult (%)	Very Difficult (%)
Yes	53	%	0.0	17.0	17.0	37.7	28.3
No	120	%	9.2	20.8	20.8	18.3	30.8

Note
[1] Sample number refers to number of respondents.
Results refer to question 17a "modal change" and question 18 "perceived crossing difficulty" (Form C, Appendix 1).

5.7 SUMMARY OF FINDINGS

The findings reported from the set-format questionnaire surveys highlight the changing patterns of perceptions and attitudes resulting from changes in traffic conditions; particularly in response to changes in traffic flow levels, and street environmental quality. Findings suggest that these changing perceptions which influence pedestrian behaviour are also a response to changes in the traffic barrier. Perceptions of street environments are therefore a useful supplement to studies of observable behaviour in that they identify reasons for changes in observable behaviour.

Conditions for pedestrians

Despite a large degree of indifference to conditions for pedestrians in Edinburgh, negative perceptions were attached to traffic conditions and variables relating to traffic related environmental quality. On Bruntsfield Place, 59.5% of residents stated that traffic conditions were bad or very bad, while 65.6% found crossing the road a bad or very bad problem. Although there are no comparable figures for Raeburn Place (due to changes in questionnaire format) traffic levels and traffic speed were seen by residents as being particularly bad for pedestrians: 66.3% cited traffic levels and 56.3% cited traffic speed as promoting bad or very bad conditions for pedestrians. Other street features such as pavement obstructions, parked cars, unloading and loading of vehicles were seen as lesser but substantial problems on both streets. Pedestrians' perceptions of and attitudes toward the pedestrian environment were also found to vary through the day in response to different traffic flow levels.

Results from the Raeburn Place survey (in which greater proportions of responses from the under 18 and over 65 age groups were obtained) indicated that respondents aged under 18 and over 65, in particular, perceived traffic levels, traffic speed, traffic fumes, traffic noise and parked cars as promoting bad conditions for pedestrians. This evidence supports that from the video study which indicated that traffic barriers are experienced to a greater extent by the young and the elderly. The Raeburn Place results suggest that low levels of trip making activity are associated with perceptions of adverse conditions for pedestrians in the street. Large numbers of elderly people were in this low trip making category, the elderly also found features of the street worse for pedestrians than respondents in younger age groups.

Respondents with a car available to them tended to state that conditions were more favourable for pedestrians than those who stated that they had no car. Car availability, clearly may affect pedestrian perceptions and behaviour.

Perceived traffic conditions and stated effects

Perceived flow levels were associated with actual traffic flow levels as recorded from the video studies by certain time periods during the day. The time periods associated with heavy traffic flow were also associated with perceptions of bad conditions for pedestrians and low levels of environmental quality.

Traffic speed was also seen to impact on attitudes towards the pedestrian environment on both streets. Although none of the respondents stated in the space provided on the questionnaire form what form this effect took, those respondents who stated that they were affected by traffic speed felt that conditions for pedestrians were bad.

Crossing location

Perceptions of traffic flow conditions were found to be linked with choice of crossing location, levels of safety and crossing difficulty. Respondents on both streets stated that heavy traffic flow resulted in them changing their crossing location away from informal to more formal crossing facilities. Results from the Raeburn Place survey also indicated that for all types of traffic condition, large proportions of child and elderly respondents stated that they crossed at Pelican crossings. In addition, respondents who found features of the pedestrians' environment bad were more likely to cross at a Pelican crossing. In particular, low levels of safety and high levels of crossing difficulty were associated with switches to more formal crossing locations.

Discouragement, deterrence and modal change

Discouragement from undertaking certain activities; switching from walking to alternative modes of transport; changing route when walking; rescheduling of trips; and deterrence from crossing the road were all found to be strongly associated with heavy traffic flows, high levels of crossing difficulty, low levels of safety and low levels of pedestrian amenity. Behavioural analysis has indicated that such traffic conditions are also associated with increased delays, smaller acceptance gaps, and with increased levels of crossing difficulty.

Crossing from behind parked vehicles

A large proportion of respondents stated that they crossed from behind parked vehicles in Raeburn Place (65.7%). A very high proportion (79%) felt that crossing from behind parked vehicles made it easier to cross into gaps in the oncoming traffic stream (79%). However, child and elderly respondents were found not to favour crossing from behind parked vehicles, and opted, in greater proportions, for formal crossing facilities as opposed to crossing anywhere. Despite the feeling that crossing was easier from behind parked vehicles this was not accompanied by any feeling of increased security or safety. This may reflect obscured views at such locations, and the need for a clear view of oncoming traffic before crossing. Most respondents did not feel that crossing from behind parked vehicles increased the feeling of security or safety (61.5%) and acknowledged that it made it harder to see oncoming traffic (66.4%).

5.8 CONCLUSIONS

The findings from the set format surveys suggest overwhelmingly that heavy traffic flows are a major constraint on pedestrian movement. Respondents clearly find crossing tenemental-radial routes a difficult and stressful experience. Many have stated that in response to adverse traffic conditions, (conditions defined by respondents as consisting of heavy traffic flows, low levels of perceived safety, high levels of crossing difficulty and low levels of pedestrian amenity), routes are changed, walking often rescheduled or abandoned altogether, and crossing locations are changed from informal to formal crossing points. The elderly and children are particularly affected.

Although designed to explore issues relating to pedestrian perceptions and behavioural response, the set format questionnaire approach was found not to deal fully with the links between perceived traffic levels and risk and behavioural response. In the set format surveys reference could only be made back to generalised descriptions of traffic conditions as stipulated in the form. This was compounded by the fact that responses were constrained to the set questionnaire format and traffic flow categories such as "heavy", "medium" and "light" which were based on a format defined by the researcher. The set format approach is also limited by an inherent inability to get close to an individual's experience and the way in which this is accounted for in the respondents' own words. This resulted in a further study using personal in-depth interviews which sought to overcome these limitations (chapter 6).

CHAPTER 6 ANALYSIS OF PERSONAL IN-DEPTH INTERVIEWS

6.1 INTRODUCTION

Although the results from the questionnaire analyses (chapter 5) complemented the findings of the video study (chapter 4), they did not fully deal with the link between the perception of traffic levels and perceived risk and behavioural response. In this chapter, this link is explored more fully using data obtained from individual personal in-depth interviews. In-depth interviews were used to obtain detailed qualitative data which would provide further insights into how people would perceive traffic and how this affects their decisions in relation to crossing behaviour.

The in-depth interviews were based around an interview guide approach which highlighted key questions (Patton, 1990) and linked with the use of a specially edited video tape (see chapter 3). It was decided to use an interview guide (see Form D, Appendix 1) rather than unstructured interviews permitting the responses to be interpreted in relation to other data which was obtained. The questions were open-ended and combined with the use of the edited video tape (which provided a framework upon which the interviews could be structured) allowed participants to express their own perceptions of the objective traffic conditions. In considering this approach, the emphasis was clearly placed on the travel experiences of pedestrians. It provides a useful complement to the techniques discussed in chapters 4 and 5.

Twenty-one respondents were interviewed individually using the personal in-depth interview approach. Each interview was recorded on audio tape for transcription into a typed hard copy format. All the typed transcripts were then analysed. Key points which were consistent with what people had intimated in their interviews were drawn from these conversations for illustrative purposes. The presentation of the data reflects the patterns and themes arising from these interviews.

Three groups were interviewed in this study: young adults, the elderly and primary school children (table 6.1). Problems were encountered with the interviews of primary school children. Data from these interviews proved very limited in all but three cases. This can be explained by a number of factors. The trend towards increased levels of parental constraint, due to perceptions of traffic danger on routes to school and in residential environments, restrict child pedestrian activity (Hillman, Adams and Whitelegg, 1990). This was evident among the children in the study. Their information and thoughts relating to the traffic environment did not appear to be particularly well developed. There were additional problems in conducting these interviews. The school room environment may have affected the quality of the interviews in some cases and the effect of having to deal with a complete stranger (i.e the interviewer) may have also affected the dynamics of the interview in terms of quality of response.

This chapter firstly highlights the age, sex and health characteristics of the sample interviewed in this study and then examines the impact of these factors on mobility levels, travel experiences and decisions related to crossing the road generally. The discussion of the findings then addresses pedestrian perceptions of traffic flow focusing on individual

Table 6.1 Age, Health and Mobility Characteristics of those Interviewed.

Cases	Age	Health and Mobility
Respondent 1 Female	66	Arthritis in legs Tries to get out as much as possible
Respondent 2 Female	84	Keeps falling, sore knees Has to be helped back up
Respondent 3 Female	87	Arthritis in hands and feet
Respondent 4 Female	67	Weakness in legs, poor circulation uses a stick
Respondent 5 Male	72	No health problems
Respondent 6 Male	69	Partially sighted, no problems with the video monitor. Active - plays bowls regularly.
Respondent 7 Male	72	Stated he had no difficulty walking, but wife said he had had a heart attack recently.
Respondent 8 Female	80	No problems
Respondent 9 Male	22	No problems
Respondent 10 Male	23	No problems
Respondent 11 Male	23	No problems
Respondent 12 Female	22	No problems
Respondent 13 Male	22	No problems
Respondent 14 Female	23	No problems
Respondent 15 Female	9	No problems
Respondent 16 Male	9	No problems
Respondent 17 Female	10	No problems
Respondent 18 Female	10	No problems
Respondent 19 Female	10	No problems
Respondent 20 Male	10	No problems
Respondent 21 Male	10	No problems

assessments of traffic conditions and perceptions of traffic and street conditions depicted in five markedly different video excerpts of objective traffic conditions, and how this affects decisions about crossing behaviour. This chapter is structured as follows:

1) age, health and mobility;

2) travel experiences of pedestrians; and

3) pedestrian perceptions of traffic flow.

6.2 AGE, HEALTH AND MOBILITY

Health problems affected the mobility levels of those in the elderly age group but not of the young adults and children in the sample (table 6.1). The elderly respondents referred to their health as an important determinant of pedestrian behaviour and activity. However, the responses obtained from this age group and the extent to which this impacted on behaviour varied markedly. Generally, respondents with health problems were very independent, although their dependence on others increased with frailty. The younger members of this age group led active lives despite health problems.

6.2.1 Older peoples' health and walking difficulties

Amongst the younger members of the elderly group with health problems and walking difficulties, there was a clear determination to overcome their resulting mobility problems. Respondent 1 (female, aged 66), although stating that the arthritis in her legs affected her travel choices, indicated that she preferred to walk as this was good for her joints. Her doctor had told her that it was important to keep as mobile as possible.

Question: "Do you experience difficulty walking due to a health problem?"

Answer: "Yes, although I prefer to walk rather than travel on buses unless it's too far. If it's not too far, I think it helps to keep the muscles moving you know".

Similarly, another respondent (case 6, male, aged 69), who was partially sighted, stated that he led a relatively active life and required no help when he was out. He did, however, indicate that he had problems identifying the numbers on the front of the bus. By comparison, older members of the group found walking more difficult. In these cases reliance on home help, friends and family increased. Increased frailty amongst this group was also associated with a fear of falling. This concern with falling and other mobility handicaps were responsible for major changes in pedestrian activity and crossing behaviour. A woman, aged 87 (respondent 3), who experienced arthritis in her hands and feet and found walking quite onerous, relied on a home help, family and friends when walking because she found she needed to take somebody's arm for support. Another woman, aged 84 (respondent 2), while indicating she did not need help when walking, was worried about falling over and being unable to get back up. Her concern with falling was found to have a marked effect on her and had resulted in her changing her previous doctor to avoid crossing a busy road to catch a bus:

Question: "Do you experience difficulty walking due to a health problem?"

Answer: "Sometimes yes, I fall now and then, I am always falling. Always fall the same way and I am frightened for my specs and when I fall I cannae get up. Some one has to always help me up.....My doctor was in the Corstorphine Road and I had to take the bus to the West End at Shandwick

Place - change there. You know I just pictured myself lying on the ground with a car on top of me. Because Shandwick Place you just can't cross it I've never been along since I'm up in the clinic up there [in Stockbridge]".

Other interviews suggested that health problems were compounded by the perceived threat of traffic which clearly affected mobility levels. This led to a greater reliance on formal crossing facilities. When respondent 1 (female, aged 66), who suffered from arthritis, was asked about her health and how this affected her decisions about choosing where and when to cross the road she explained:

"Crossing the roads I feel terribly tight you know, I get myself quite tight crossing the roads sometimes because you don't know how quick......I always cross at lights because of the amount of traffic in Edinburgh alone".

Similarly, respondent 6 (elderly male, aged 69), who was partially sighted stated that he also relied on formal crossing facilities because of his health:

"It affects me in as much that I always go to the green man".

Respondents, however, also feared for their own safety at formal crossing locations. In the case of Pelican crossings, they expressed concern that drivers did not stop and travelled straight through the green man phase at the lights. They also felt that the green man phase was too short to permit crossing in safety. This prompted concerns among the more frail respondents in the elderly group indicating that if they rushed to cross, they might fall in the carriageway:

Question: "How does this (health) affect your decisions about choosing where and when to cross the road?"

> Answer: "Well when I cross the road, you see, when the green man goes you don't get much time and they say take your time, take your time but you can't take your time, it's impossible. And I am always frightened when I am hurrying across the road I'll go down and a car will come on top of me" (respondent 2, female, aged 84).

This fear for their safety at crossing facilities, as a result of drivers failing to stop, also created greater vigilance. When asked how her health affected her decisions about choosing when and where to cross, respondent 3 (female, aged 87), who suffered from arthritis in her hands and feet, stated:

> "You have to be careful, I mean Raeburn Place is very busy, sometimes they don't stop, there's the green man, sometimes they won't stop, you got to watch".

Concerns about safe crossing locations were not confined to older people with health problems. Other elderly respondents who regarded themselves as relatively fit and healthy also stated that they crossed at Pelican crossings or at light controlled junctions because it was easier:

> "I've got to be very careful where I'm crossing, I've got to find a crossing because in Raeburn Place and on other streets, the traffic doesn't give way" (respondent 5, male, aged 72).

Concerns about the traffic not stopping at formal crossing facilities was also shared by the children and their parents.

6.3 TRAVEL EXPERIENCES OF PEDESTRIANS

Responses to questions aimed at identifying factors which affected the pedestrian travel experience generally and travel patterns were interspersed with references to crossing the road and the use of crossing facilities. The responses, however, confirmed the different pedestrian activity patterns identified in chapters 4 and 5 for the three age groups.

Pedestrian travel amongst the elderly respondents was characterised by longer walking trips associated with leisure activities, especially during the summer and shorter, local journeys principally associated with shopping and visiting friends on Raeburn Place or in the Stockbridge area. Pedestrian travel for the young adult group principally focused on weekday trips to and from college. These journeys were characteristically undertaken everyday during the week and usually lasted around 20-30 minutes. Often these journeys to college were undertaken from the inner suburbs and involved the use of a combination of modes on one trip; for example, bus use combined with walking. During the evening and weekends, walking trips were associated with leisure activities and part-time work. An important feature of pedestrian journeys among this age group was the lower levels of avoidance of main roads and the greater willingness to cross them.

Typically, travel patterns for primary school children were based during the week on trips to and from school. Children were often accompanied by friends or parents on these pedestrian journeys. Several children indicated that they were given lifts to school in the car by a parent and then picked up again in the afternoon. High levels of accompaniment and low levels of independent pedestrian activity, sanctioned by parents, is apparent for this age group.

The interviews raised a number of issues reflecting concern with pedestrian crossing usage and how their location affected route choice. The crossing of side roads was also seen to be an important issue, although to a lesser extent than on main roads. Past experiences of the pedestrian environment influenced elderly pedestrian behaviour. They avoided periods of heavy traffic flows, and rescheduled their pedestrian crossing activity. Finally, parked cars were identified by many of the interviewees as a street feature which promoted perceptions of lower levels of safety.

The patterns and themes identified and discussed in this section relate to the following:

1) Route choice and crossing main roads;

2) Crossing side roads;

3) Personal experience;

4) Rescheduling activity;

5) Parked cars.

6.3.1 Route choice and crossing main roads

Older people

The interviews indicate that the location of crossing facilities on main roads is an important consideration on all pedestrian journeys and that the provision of pedestrian crossing facilities is seen as important in mediating the perceived threat of traffic on these routes. In the evening, when traffic conditions were thought to be less busy, the provision and location of crossing facilities was still seen as an important feature of trips taken by elderly pedestrians. Respondent 1 (female, aged 66), who suffered from arthritis, indicated that she crossed at Pelican crossing facilities and that their location was an important feature of her route planning.

Question: "Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?"

Answer: "I usually take quite long walks. I walk from Newington down to Granton, but of course because I was on my own so I was more or less on the one side until I got down to the bottom of the Bridges I had to cross at the bottom of the Bridges to the corner of Princes Street.. and then I walked right down ... that's a bad roundabout because sometimes you have to cross over there's so wider space to get across the road you know, you need to go practically in to York Place before you could cross the road to get on to the other side. So what I usually do is I come down to the lights and cross and walk down at the Playhouse I get quite agitated at crossing London Road".

She also indicated that these trips were undertaken daily during the summer in the evenings when it was quieter and there were not so many people around. During the winter she stated that she shopped locally because it was too dark in the evenings. When she was asked what the traffic conditions were like when she was out walking, she also indicated that she did not like being pushed. This fear may be linked to her recent fall, after which she had been hospitalised. She replied:

"Well it's a bit quieter at night time that's the only time you can have a decent walk without being pushed you know, because during the day they are all out getting there messages and one thing and another you know. At night time the streets are a lot quieter so that's when I usually go for my daily walk".

Respondents 5 and 6 gave very detailed accounts of their travel patterns and also highlighted the importance of crossing facilities on their chosen routes. Despite being partially sighted, respondent 6 (male, aged 69) was very mobile and independent. The location of crossing facilities was very important to his travel patterns. It is apparent that crossing the road at locations without a Pelican crossing or a light controlled crossing with a pedestrian phase, was problematic and often threatening. This respondent only walked along main roads where he knew a Pelican crossing would be located. Furthermore, he was extremely concerned with the tendency for car drivers and cyclists to ignore the pedestrian phase at crossing facilities. As with respondent 1, the location of pedestrian crossing facilities was essential in the choice of route.

> Question: "Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?"
>
> Answer: "Walked down to the Powderhall on the Monday, I walked along by Warriston and then I crossed over (at a crossing) and walked along the Pond Side which was fairly easy. On Tuesday I went shopping at Sainsburys and that roundabout at Comely Bank is quite nasty - could do with a green man actually. That was about half past ten in the morning. I bowled all day at Powderhall. Thursday I went down to North Berwick. That's another problem of mine, the destination signs on the buses are all too small for me you know. Friday I wandered about the town I went up and along Princes Street which is quite handy for me because you have the green man at the crossings and down Queensferry Road to Orchard Brae and down. There's a bit, Randolph Crescent is it ? Where the traffic turns round that's a very dangerous bit. The traffic is coming from both sides you don't really get an opportunity to cross over because when it's coming

down off the other side and down and it goes on until the lights stop and then they are coming off Queensferry Road and down so the pedestrians just have to pick their time......I only go on main roads where I know that there is a green man. Another problem is, seems to be getting more regular, is cars and cyclists going through the green man".

Similarly, respondent 5 (male, aged 72) explained that when accompanied by his cousin, who experienced mobility problems due to poor health, he avoided busy main roads where possible. For longer trips visiting relatives they relied on the bus. Walking was principally an activity associated with leisure activities. Problems were encountered when they tried to cross to the bus stop in Raeburn Place. The interview indicates that in light traffic conditions, crossing to the bus stop was easier. When the traffic conditions were busier, the respondent stated that the only way across the road was by crossing at a pedestrian crossing facility. This often involved a detour.

Question: "Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?"

Answer: "I normally meet my cousin who can't walk very well at 10 o'clock in the morning and we sometimes come up Dean Street and other times we come along Raeburn Place now if on a Monday for instance we collect our pension at the post office along here and then we have to, we don't have to, but we normally go on a Monday to visit his sister on Ferry Road. So we go back here [in Raeburn Place] and cross sometimes if the traffic is fairly light we may manage to cross to this bus stop here failing that we walk back again and cross up here [at the traffic lights] at the Dean Street end and walk back to the bus stop and we get a bus up town to Hanover Street and then get a bus to Ferry Road. Well sometimes we walk along and go into Inverleith Park and may be walk around the pond there and have a seat there. Then during the season when Broughton Film Theatre is on we go to that regularly, every other Friday and we will normally walk along to East Fettes Avenue and take a slow walk up to the theatre."

When asked about crossing main roads respondent 5 indicated that when on his own he travelled by bus to the city centre and then walked to the pub to meet friends. Prompts which sought to find out further information, highlighted the difficulties experienced when accompanied by his cousin.

> Question: "Do you have to cross any busy main roads?"
>
> Answer: "We tend to avoid them really. Personally from my own point view I don't meet him on a Friday and I go from here to the Abbotsford and have my lunch there and meet some friends there. And I come across here and I get the bus to St. Andrews Square and walk around and go down in to Rose Street to the Abbotsford. On Saturday I go to the Doric in Market Street where again I meet some friends at lunch time. Sometimes I get the bus if a 28 or 29 is coming I get one of them and it takes me up the Mound. If a bus comes into St. Andrews Square I get that one and then walk down into Princes Street and down Waverley Bridge. But I can do that. If my cousin was with me, we couldn't do that."

In response to a question aimed at seeking further information relating to shopping trips, it was evident that route choice was often constrained by seating provision. This was seen as an essential pre-requisite for his cousin who needed to rest when out walking, even on shorter distances.

> Question: "Do you walk on shopping trips?"
>
> Answer: "Well as I say normally my cousin is with me and he can't walk very far and if we are walking or making for anywhere we have to try and make route where there is a seat so he can sit and have a rest. At the moment I am quite fit and have no problem".

Respondent 7 (male, aged 72) indicated that walking was primarily associated with leisure, although his wife walked to the shops. The respondent also indicated that he crossed main roads at Pelican crossings or at light controlled junctions and that this made the crossing task easier.

> Question: "Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?"
>
> Answer: "I go bowling during the week walk from house in Comely Street to Powderhall. Across the main roads Broughton Street. There again I use the green man just press the button and you can get across no problem. My wife goes shopping on Raeburn Place. I have no problem with the traffic. Down Broughton Place, Eyre Place it's pretty busy. I cross at the lights on Dundas Street. When the opportunity arises I cross you know".

Although crossing at Pelicans and light controlled junctions was seen as essential in order to get across busy main roads in relative safety, statements of use, particularly amongst pedestrians who were more frail and those who had been involved in accidents or near misses as pedestrians, also included concerns for their safety at formal facilities during a period of pedestrian precedence; principally those periods associated with the "green man" phase. For these groups, levels of perceived safety were relatively lower at such crossing facilities. Respondent 2 (female, aged 84) relied on her sister to do most of her shopping but indicated that she crossed at the light controlled junction at Hamilton Place because the "green man" was longer. Despite this, and due to a combination of frailty and fear of falling over, crossing at the lights did not guarantee that she could cross in safety. These perceptions are again associated with the insufficient time of the "green man" period of pedestrian precedence which forced her to rush across the road.

> Question: "Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?"
>
> Answer: "I never go out at night, I usually go from here [day centre] home and that's me usually, but I'll be honest there are times you can hardly get across the road and then you are half way through you do and then the traffic starts again. The green man is not long enough. Now I went up the road this morning and the green man had been on by the time I got to the top it went off. The green man went on but I could not get there in time so I did not get across the road" (case 2, elderly female, aged 84).

Similar experiences were also encountered by others with mobility problems in this elderly age group. Fear of crossing and having to rush across were also associated with the rescheduling of pedestrian crossing activity. Respondent 3 (female, aged 87), who suffered from arthritis, while indicating that she was largely house bound, stated that she only made local trips to the shops and hairdressers along Raeburn Place on one side which meant she avoided crossing Raeburn Place altogether. Respondent 4 (female, aged 67), who walked with a stick, also indicated that most of her walking trips were local shopping trips along Raeburn Place. When describing a typical week's journeys as a pedestrian, she indicated that this was "Quite handy because I don't have to cross any roads".

Respondent 8 (female, aged 80) also stated that she was fearful of crossing the road and relied upon help from a friend. Being accompanied boosted her confidence and helped guarantee her a safer crossing, despite perceived low levels of safety. When asked how the traffic affected her she stated:

> "I'm a wee bit nervous of crossing, you have got to watch, but as I say the green man and traffic signals are alright and that, but it is a bit nervy on you own. In fact the person I go with I say come on Kathy we'll go to the crossing, she's the greatest young thing, sometimes on her own she crosses not at the lights."

Young adults

Amongst the young adult age group, weekday trips were dominated by travelling to and from college. Pedestrian trips in the evenings and at the weekend were associated with leisure activities, journeys to work and shopping activity. By comparison with the elderly pedestrian group interviewed in this study, there was less concern with the location of crossing facilities on their routes, although it was acknowledged that it is safer to cross at such locations. Route selection by this age group was based on assumptions of traffic level and the directness of the route in relation to their own destination.

Respondent 9 (male, aged 22) indicated that he regularly crossed main roads on his journeys to and from college in the morning and late afternoon. These journeys were supplemented by trips associated with leisure activities and work in the evening. One of the main roads was crossed at a pedestrian crossing located on the route. The respondent also indicated that he crossed another main road outside the college but he admitted that he did not use the crossing provided. Instead, he crossed near the crossing at a location which involved no detours and which enabled him to utilise the gaps in the oncoming traffic, resulting from the operation of the Pelican crossing. In other words, he was using the crossing opportunities resulting from gaps occurring in the oncoming traffic stream. This strategy was quite different from that of the elderly who relied heavily on pedestrian crossing facilities to get across the road.

> Question: Do you have to cross main roads at all?
>
> Answer: "I have to cross Melville Drive, in the Meadows, but there is a pedestrian crossing there. And I suppose Lauriston Place outside the College although there is heavy traffic there, it's not too much of a problem there because of the junction and the traffic stops there is also a pedestrian crossing further down the street which causes breaks in the traffic. I always use the crossing though on Melville Drive. I would not usually use the crossing outside the College in Lauriston Place. I usually cross in front of the bus stop" (respondent 9, male, aged 22).

The respondent indicated that this route, combined with the crossing opportunities, was quicker and the most direct. Although he felt traffic conditions were generally heavy, he also believed that the traffic conditions did not really affect him when he was a pedestrian. His perception of traffic conditions and their effect upon him were clearly reflected in his crossing behaviour on main roads. This crossing strategy clearly reflects a tendency to minimise delays encountered on the route.

> Question: How do the traffic and street conditions affect you as a pedestrian?

Answer: "I would not say that it affects me, I've been in Edinburgh for the last five years I know the traffic is heavy in Edinburgh but I would not say that it affects me."

Respondent 10 (male, aged 23) also indicated that his trips into college everyday during the week were supplemented by trips into the city centre of Edinburgh at the weekend. However, this respondent was more concerned with the traffic levels he encountered on his pedestrian journeys. He indicated that crossing the road to the bus stop was problematic because there were no pedestrian crossing facilities leading directly to the bus stop.

Question: Thinking back to a typical week, perhaps last week, where did you go out as a pedestrian? Where did you go?

Answer: "Walked into town on Saturday and Sunday, on Inverleith Row I have to cross the road to the bus stop and there are no crossings. It's a bit of a headache in the morning rush hour. Food trips, once a week to a super market and once a day to the local shops. At night I walk into town when I am going out. I also walk into college every day."

He also indicated that he crossed main roads on journeys into college during the week and that when the traffic was heavy, he crossed at a pedestrian crossing. He did not specify a particular time which was associated with these journeys but did indicate that he felt the traffic on the main roads in the centre of Edinburgh was heavy during most of the day. He was particularly concerned with the level of provision for pedestrians. He had mentioned that the location of pedestrian crossing facilities was often inadequate and commented on the lack of proper pedestrian crossing facilities at a roundabout which was often encountered on his route to college. He believed crossing facilities were essential for crossing the road during periods of heavy traffic flow. During periods of relatively light traffic conditions, he said that he crossed anywhere.

Question: Do you cross main roads?

Answer: "Yes, I cross Inverleith Row and Princes Street when I am coming up into the Old Town and then the junction at Deacon Brodies is a busy junction. On a shopping trip I have to cross Inverleith Row, there is a roundabout on this journey which I have to cross which isn't very pedestrian friendly."

Question: Where would you cross these main roads?

Answer: "Depending on the time of day if the traffic was quite heavy I'd tend to go to a pedestrian crossing, but at night when the traffic is not as heavy I would just cross anywhere."

Traffic during the rush hour along Princes Street in particular was believed to be intimidating. In these situations he used the pedestrian crossings provided but also admitted that even when using crossing facilities, he sometimes did not feel safe.

Question: How do the traffic and street conditions affect you?

Answer: "I think the traffic during the rush hour can be quite intimidating on the main routes particularly on Princes Street, and to be honest I don't think the pedestrian crossings on Princes Street are very helpful, they are not very friendly, and some of the roads in the Old Town in particular you've got to look right behind you to see if cars are coming up and turning left or right depending on which side of the road you are at. Sometimes you are tired and you don't look.....Depending on the density of the traffic this affects whether I cross the road at all or whether I go to a crossing. If there is not so much traffic I tend to be not so careful, just look each way once may be. On essential trips I am a lot more careful, on optional trips particularly trips you are familiar to, you just get accustomed to walking, doing a certain trip".

The location of crossing points on main roads was also an important determinant of the pedestrian route taken. When asked how the traffic affected him shopping trips the respondent indicated that:

> "I am used to like shopping for instance, I take the same route, I cross the road at the same point, but if it is an important journey and a route which I don't know, I will cross at the designated crossing points".

The effect of traffic and the crossing strategy adopted was further qualified by a distinction between optional and essential trips. Essential trips were associated with a greater need to cross the road which the respondent indicated resulted in the need to be more careful when crossing. He also felt that he was less attentive of traffic conditions.

Traffic conditions were an important factor which determined the route choice for respondent 11 (male, aged 23). He indicated that although the route he often chose was not as direct as alternative routes it was more pleasant because it had less traffic. The lower traffic levels on his chosen route made his journey less stressful.

> Question: How do the traffic and street conditions affect you?
>
> Answer: "The route I take from here to work is slightly longer than it would take me to go up Morningside Road up by Bruntsfield. The route I take is more or less devoid of traffic. It's just a nicer route. Also the route I take from College, it is quicker to go along Lothian Road, but on Castle Terrace there is less traffic. It's less stressful".

Although respondent 11 said that traffic flow level was an important determinant of his choice of route, he also indicated that for important journeys, where there was a time factor, he took the quickest route irrespective of the traffic conditions.

> Question: Are there certain street features which affect your decisions?
>
> Answer: "Normally it would be the flow of traffic and how easy it would be as a pedestrian to get across roads. For more important journeys and if I was running out of time, I would take the quicker route whatever the traffic conditions".

In other interviews, traffic levels were also important determinants of the choice of crossing location and route. Respondent 12 (female, aged 22) indicated that she crossed Lothian Road (a main road) at a Pelican crossing on her walking journey into college because she felt it would be too dangerous to cross anywhere else.

> Question: Do you cross any of the main roads at all?
>
> Answer: "I cross Lothian Road, at the pedestrian crossing by the MGM cinema. I wouldn't cross anywhere else because it is too dangerous. Coming in to college, the traffic, it's just beginning to ease up, but Lothian Road is always busy, it's quite heavy with traffic. Then coming back at 5 o'clock the traffic is heavy then".

She also explained that she would reschedule her trip to another time if it coincided with the rush hour. However, like respondent 11 she felt she would ignore the traffic conditions if the trip was important. Respondent 13 (male, aged 22) stated he felt that the traffic was not particularly threatening but indicated that he sometimes liked to avoid those roads with high levels of traffic.

> Question: How would the traffic conditions affect you?

Answer: "I suppose it's down to the traffic that I normally go via the Meadows rather than walking down the main road, to save having to cross roads or having to walk with the traffic. I'd rather avoid it but then occasionally, if it interests me, I'd take another route. Although the traffic is heavier on other routes, it does not really put me off, sometimes these streets can be interesting places to walk down".

Children

It was evident from listening to children that they are subject to parental constraints (reflecting perceptions of traffic danger) on routes to and from school and generally. This concern with child pedestrian safety was reflected in lower levels of independence. The children, who were interviewed in this study, were frequently accompanied by parents or friends on pedestrian trips.

Respondent 19 (female, aged 10) indicated that her mother gave her a lift to school in Stockbridge every day on her way to work. She explained that this was because her mother was concerned about her crossing main roads on her own:

"Mum, she sometimes worries about the traffic, she does not let my brother (aged 7) cross the roads on his own, I have to be there".

Although she indicated she did not usually cross main roads, she also stated that when her mother parked the car near the school, she had to cross the main road outside the school. Her mother sometimes helped her across the road.

Question: Do you have to cross main roads at all?

Answer: "Yes, sometimes my Mum parks in Clarence Street and we have to cross the road, or Saxe-Coburg if she parks there. It's not very busy the times when we are there on our way to school and sometimes in the Stockbridge Road there (Hamilton Place) my Mum takes us across because she thinks it's busy there".

Other interviews with children indicated that there was a crossing patrol in operation on the main road outside the school in the morning.

On the main roads she indicated she felt unsafe due to the high levels of traffic encountered on these routes and her Mother encouraged her to use pedestrian crossing facilities.

Question: Are there any times you feel so unsafe you won't cross the road?

Answer: "Really busy roads, there is a really busy road, cars come out of this big junction [roundabout] and it's really hard to cross because you have to check that none of the cars are coming. It's up at Leith Walk, near the bakers and Post Office. Sometimes I don't want to cross because it is really busy and sometimes my Mum says cross here and I go across at the green man".

Concern about crossing main roads was also experienced by respondent 15 (child, aged 9). This concern was shared by her parents. She indicated that her parents did not mind her crossing the road on her way to school because she was with friends, but they did not usually let her go too far away.

Question: Do your parents take you across the road?

Answer: "Yes, sometimes, well when they are usually with me they don't like me to go too far out on my own. Except for going to school, they don't mind then because I usually meet up with friends on the way so that I can walk with them."

During a typical week she always crossed at the Pelican crossing to get to the bus stop. On her trip to Brownies, which involved crossing a road without the assistance of a Pelican crossing, she was accompanied by friends. Traffic levels were however not high on this journey.

Question: Thinking about a typical week, perhaps last week, did you go out as a pedestrian? Where did you go?

Answer: "Monday, I just like walked to school and took the bus, then walked back to the bus stop after. At the bus stop I cross at the green man. Tuesday, I walked to French classes, at Eyre Place (near the bus stop). Wednesday, I went to a friend's house and then we go off to Brownies and then they drop me off in their car at my house."

Question: What route did you take?

Answer: "We go from Brandon Terrace and we walk up to the junction that I cross where the bus stop is and cross the road there and we cross at Henderson Row and then we walk up there to Cumberland Street and we walk along there and then you get to the end of that there's St.Stephens church and it's in there inside the door."

Question: Are there any roads you have to cross there at all?

Answer: "Well there's the two at the junction and then when you walk up you have to cross Fettes Row and then you have to cross to get to the church....You have to keep your eyes open, it's quite quiet but you just have to keep looking anyway".

Although her parents feared for her safety, she felt that her parents behaviour was sometimes contradictory when they accompanied her. They did not always cross at the pedestrian crossing after telling her to do so all the time. In these circumstances, she indicated that she did feel unsafe when they took her across the road with them.

> Question: Any problems or difficulties you experience when you are out walking?
>
> Answer: "Mmm, one thing I don't like is my Mum and Dad, we stop at the green man and they say we all have to cross at the green man, they are always telling me that. And then the green man, we know it all works because everything lights up and they just cross, that's what I don't like and I try to hang back and wait for the green man but they just pull me across. I don't like that. They say they are making a parents decision."

Respondent 21 (male, aged 10) also indicated that his parents told him to cross at the lights because it was much safer. He found that crossing the road (Hamilton Place to school) was safe because of the School Crossing Patrol.

> Question: If you think back to a typical week, did you go out as a pedestrian, where did you go ?
>
> Answer: "Last week we didn't do much really. Monday, walked to school and walked to my friends, which is just across the road from the school and go to Jamie's [Leslie Place] and James who lives in Hamilton Place. I cross at the lights, it's much safer there. My parents tell me to do that, they worry about my safety. Tuesday, the same as Monday. Tend to do the same all week. Sometimes go shopping at Scot-mid on Hamilton Place" .

He also stated that he found the traffic conditions in Edinburgh annoying because sometimes cars were found to drive through the lights.

6.3.2 Crossing minor roads

The response about crossing side roads were mixed by comparison to those about crossing main roads. Some of the elderly respondents experienced difficulties on minor roads; none of the young adults encountered any problems on these roads. For example, respondent 3 (female, aged 87) indicated that traffic conditions on side roads were better than on the main roads although parked cars in the street outside the day centre (Cheyne Street) were sometimes a problem.

> Question: Are there circumstances where you feel so unsafe you won't cross the road?
>
> Answer: "Sometimes, it depends how you are feeling you know. Raeburn Place is getting more bad. Cheyne Street [the side street] is not too bad, the cars should not be there you know".

Perceptions of safety on side roads were principally associated with traffic travelling through the lights when they indicated a pedestrian precedence phase and the speed of traffic. Traffic speed was not referred to as a problem for pedestrians on main roads. Respondent 1 (female, aged 66) indicated that the traffic affected her just as much on the side roads.

> Question: Does the traffic affect you just on the main roads ?
>
> Answer: "Oh no, sometimes the traffic can affect you just as much on the wee side roads, you know...sometimes you can get to the side roads and the drivers do the same as on the main roads, they go through the lights".

Traffic conditions and driver behaviour had clearly affected her crossing activity. This was linked to her experience of being knocked down in a pedestrian accident. Further analysis indicated that she adopted her crossing strategy in light of this accident and mobility constraints resulting from her arthritis. The evidence from the interview indicated that she restricted walking in the summer evenings, when there was less traffic and fewer people around. This minimised her crossing problems and reduced the impact that the traffic levels had on her during the day.

Respondent 5 (male, aged 72) indicated that high traffic speeds in a more suburban setting, away from the relatively congested Stockbridge area, that high speeds were a problem on the larger side roads. Crossing problems in these circumstances were exacerbated when accompanied by his cousin who had health and related mobility problems. Although he viewed crossing facilities as essential in such situations, there was no evidence that he rescheduled his journeys to avoid such conditions.

> Question: Do those conditions affect you as much on the smaller roads?
>
> Answer: "Yes, for instance Ferry Road, I have a cousin who lives in Winnel Road just off Ferry Road and now, going there and the traffic along Ferry Road in both directions, they are speeding a lot, you have to use the crossing you can't take a chance. Princes Street you certainly, unless you are an idiot, you have to use the crossings. Well you know what it is like. The only way to curb, that is restrict traffic in the city....Well, minor roads, again depends on the density of the traffic, I mean some minor roads can be even more dangerous because there is very little space between the cars and to try and cross it would be ridiculous unless there's a crossing".

Younger adults, by comparison, seemed to encounter few problems on side roads. Respondent 10 (male, aged 23) indicated that traffic conditions could usually be described as light on the side roads and that in general he had no problems crossing these roads.

Question: How do conditions affect you on the more minor roads?

Answer: "In my experience, the traffic is pretty light, except in the Old Town where they are doing some road works. At the minute you tend to find cars are getting in and around everywhere. I usually find the traffic quite light and I don't have any problems crossing the roads".

This type of experience was commonplace amongst this age group. Respondent 12 (female, aged 22) indicated that the lower traffic levels on the minor roads meant that she thought less about the traffic and was often less cautious about crossing the road.

Question: How do conditions affect you on the minor roads?

Answer: "On major roads I think more about the traffic. On minor roads I take more of a chance. If it is heavy traffic I am more cautious about crossing the road, I feel you have to be more careful. If it's a minor road you become a bit more slap dash about crossing".

Similar responses were also found amongst the children interviewed in the study. Frequent references were made to the lower traffic levels and the more relaxed approach to crossing the road in such situations. In describing the difference between crossing on a main road and a minor road, respondent 15 (female, aged 9) described this more relaxed approach.

Question: Do you find your behaviour changes in different situations?

Answer: "Well yeah, sometimes it's like 'Are you sure we can cross here?', like you feel like 'What if a car comes ?' [on main roads], and small roads it's like they take everything for granted they are so quiet and you just cross.. the traffic does not bother me as much on smaller roads".

However this sentiment was not shared by all the children. Respondent 21 (child, aged 10) indicated that he sometimes found side roads frightening because of the higher speeds which are sometimes reached on these streets.

> Question: Are there any circumstances when you feel so unsafe you won't cross the roads?
>
> Answer: "Mmm, yes when there are no traffic lights around, on minor roads it's quite scary because a car would come around any second".

6.3.3 Personal experiences of the elderly

Personal experience is clearly an important factor which influences perceptions of safety. In the case of respondent 1 (female, aged 66), previous bad experiences had accentuated fear of crossing the road. She explained that several years ago she had been involved in an accident as a pedestrian and this contributed to her fear of traffic. This may also help to explain why she confines her walking activity to summer evenings when there is less traffic on the roads.

> Question: You mentioned about being knocked down, could you tell me about this?
>
> Answer: "Yes I was knocked down at Drumsheugh Gardens, I was coming from my work I was at the lights it was at go and I went to cross and this car came up.....He went right through the light and smacked me, I got up and I walked away a lorry driver had been sitting further down the road and he came up and he says to me do you want me to get you seen to no, no I said I'm alright but I had to go to hospital some weeks after because I'd torn my ligaments......Ever since I've been afraid of the roads you

know. ...I have fallen since. I fell in Junction Road just last year, It was sort of like a dizzy spell my friend had to take me home in a taxi and the doctor put me in hospital for tests for a few days.. so I am really afraid of roads".

Similarly, respondent 3 (female, aged 87) indicated that she had almost been knocked down at a pedestrian crossing in Edinburgh during the "green man phase". This experience had worried her for a few days afterwards, and she stated that she still did not feel completely safe at pedestrian crossing facilities. Her response indicated that she was worried that the traffic would not stop during periods of pedestrian precedence:

"You get a bit nervous there is no doubt about that because the traffic is getting really bad....as I told you trying to cross is really difficult, you have got to watch. Some of them nay bother they just drive on your not supposed to be there sort of style you know".

Question: Has this happened to you?

Answer: "Yes a Police car on Raeburn Place, I think they were chasing somebody though, I was just going to step out.. If I'd have stepped another step I would have had it. I had a bit of a shock, it worried me for a few days after".

6.3.4 Rescheduling pedestrian activity

Indications from the elderly group suggest that those with mobility related health problems were prone to reschedule their walking trips to avoid busier periods during the day. Some rescheduling of activity was found amongst the younger adults as a result of adverse traffic conditions, although this appears to be on a much smaller scale than that associated with the elderly. None of the children involved in the interviews indicated that they would reschedule their pedestrian activity to avoid heavy traffic. This probably reflects constraints resulting from the need to attend school during the week and parental restrictions that result in little opportunity to reschedule activity.

Respondent 3 (female, aged 87) who had almost been hit by a vehicle at a pedestrian crossing stated that she rescheduled her trips to times during the day when the traffic was less busy:

> "The difficult time is around 5.00 p.m. you would have to avoid trips around then".

She also explained that she re-arranged her journeys in the morning when it was less busy. This rescheduling activity clearly improved her perceptions of safety on Raeburn Place.

> Question: Do you re-arrange your journeys to avoid traffic?
>
> Answer: "You have to, the earlier you're out, the better. Later on the traffic seems to get worse you know".

Similarly, respondent 4 (female, aged 67) indicated that she tended to avoid the periods during the day associated with heavy traffic flows. When asked about the time of day her journeys were usually undertaken, she indicated that she went out "earlyish in the morning you know when the traffic is not too bad or in the afternoon...I think that there is too much traffic in Raeburn Place for one thing I mean there is heavy lorries which use it and it really is quite a narrow place". Not only did she indicate that she would reschedule her journey according to traffic conditions, but that she would also avoid crossing the road. She explained that she would use the shops on one side of Raeburn Place to avoid crossing.

Question: Are there any circumstances when you feel so unsafe that you won't cross the road at all?

Answer: "Well if there is too much traffic then I will probably shop on the one side and not bother crossing even though there is a Pelican".

This sentiment was shared by respondent 8 (female, aged 80) who indicated that she would avoid the peak periods altogether. Under these circumstances she felt even crossing at the lights in such traffic conditions was unsafe.

By comparison, those respondents in the elderly group with no health or mobility problems stated that they would not reschedule their journeys at all and that there were no circumstances in which they felt so unsafe that they would avoid crossing. When respondent 5 (male, aged 72) was asked if he would consider rescheduling a pedestrian journey due to the traffic conditions he replied:

"Personally, no, unless I have an absolute deadline appointment and I find I can't get across the road, the traffic is so dense, I find I get a bit frustrated and agitated, not agitated but annoyed. I'd wish the damn things and let me across you know".

Evidence of rescheduling amongst the young adult and child groups interviewed in this survey was limited. This reflects higher mobility levels due to good health which reduced the need to reschedule activity since more flexible approaches to crossing the road can be adopted. In addition, the lack of rescheduling may reflect time constraints associated with journeys to and from school and college. For children, low levels of rescheduling may also reflect accompaniment by parents and time constraints associated with the school day. Amongst the young adult group, only respondent 12 (female, aged 22) indicated that she would reschedule her trip, as long as it was not important, in the early evening to avoid the rush hour.

"If it's the rush hour I probably would think again and re-arrange my trip to a different time. If it was an important trip I'd go and ignore the traffic".

6.3.5 Parked cars

Parked cars were highlighted as a particular street feature which caused problems for the elderly. However, only one young adult interviewed found parked cars a problem. Parked cars presented a number of problems to pedestrians including causing obstructions on the pavement, making it harder to find a place to cross the road, and causing problems at bus stops; forcing buses to stop further away from the kerb thereby leading to increased feelings of insecurity.

Respondent 6 (male, aged 69), who was partially sighted, found parked cars a problem when they were on the pavement.

Question: How do the traffic and street conditions affect you?

Answer: "I would not say that they affect me a great deal. Cars parked on pavements affect me a great deal. Recently I walked into the driving mirror of a parked car I got quite a bit of abuse, I felt that it wasn't my fault".

While respondent 1 (female, aged 66) indicated that parked cars obscured her view and drivers' views when she was trying to cross the road. This reduced her feelings of safety and raised her anxiety about crossing the road.

Question: Are there certain features of the street that affect your feelings about the safety?

Answer: "Yes, parked cars because sometimes you don't see a car and if you have to cross between cars there could be one which comes very quickly along the road".

Similarly, respondent 12 (female, aged 22) found parked cars a problem when they were in the vicinity of pedestrian crossing facilities. She stated that parked cars and vans around Pelican crossings made her feel more cautious.

Question: Are there certain street features which affect your feelings?

Answer: "I usually don't really worry about the traffic, I'm not really bothered by the traffic but I am more cautious when you get vans and delivery trucks parked around Pelican crossings in case something comes".

Respondent 3 (female, aged 87) indicated that parked cars were a problem at the bus stop. She found this a frightening experience because she never felt sure if the cars were going to move while they were waiting to board a bus, or trying to cross after alighting the bus.

Question: Are there certain features of the street that affect your feelings about the safety?

Answer: "Some of them park too near the stop, you are frightened to move because you think they are going to start to move or something you know".

6.4 PEDESTRIAN PERCEPTIONS OF TRAFFIC FLOW

Traffic flow has been highlighted in both the set format questionnaire survey and the video analysis of pedestrian behaviour as an important determinant of pedestrian behaviour on tenemental-radial routes in urban settings. This section focuses on the qualitative data obtained from the individual personal in-depth interviews which refer to pedestrian perceptions of traffic flow. The weakness of the set-format questionnaire was that data relating to the impact of traffic flow was analysed according to pre-conceived categories of flow which were stipulated on the questionnaire forms. Clearly, categorisation of traffic flow in this fashion ignores the problem of relating perceptions of traffic conditions to a particular context and the variations in perceptions of traffic flow and the wider implications that this has for behavioural responses at the individual level. The development of the in-depth interview approach in this study sought to overcome this problem by incorporating the use of a specially edited video tape. This provided the context within which perceptions and their impact on pedestrian behaviour could be assessed and enabled the qualitative data obtained to be related to an objective traffic condition.

The next section (6.4.1) is focused on the individual threshold assessments of traffic conditions and in a further section (6.4.2), perceptual data on crossing the road in five different situations, with markedly different traffic flow levels, is presented. For the threshold assessment, interviewees were played a specially edited continuous tape, lasting three minutes, in which traffic was seen to gradually increase in volume on Raeburn Place. After watching the tape for the first time, the tape was rewound and the interviewees were asked to indicate when they felt that the traffic was no longer light. At this point the tape was stopped and the timing was recorded from the video counter. The tape was then restarted and respondents were then asked to indicate when they thought the traffic was heavy. Respondents often found this task problematic due to the platooning which often occurred in certain excerpts. For example, platooning can result in gaps in the traffic flow in a given 15 second excerpt of tape, even though traffic flow could be categorised as heavy for that period.

The interview design was also based on an innovative approach which combined the use of selected excerpts of video tape which were edited specifically to show five different traffic conditions. This approach sought to place the interview within some context. The five excerpts were:

1) Heavy traffic flow - 6-9 vehicles per 15 seconds;

2) Congested traffic flow in both carriageways - build up of stationary vehicles in both carriageways, over 9 vehicles per 15 seconds;

3) Congested traffic flow in one carriageway - build up of stationary vehicles in one carriageway, over 9 vehicles per 15 seconds, and a medium level of traffic flow in the other carriageway 3-6 vehicles per 15 seconds;

4) Medium traffic flow - 3-6 vehicles per 15 seconds;

5) Light traffic flow - 0-3 vehicles per 15 seconds.

The same questions for each excerpt were used and were aimed at eliciting responses relating to perceptions of traffic and street conditions to feelings of safety and risk, and crossing behaviour.

6.4.1 Threshold assessment

Individual threshold assessments of the respondents involved in the interviews were undertaken to obtain data on perceptions of traffic levels and the levels at which individuals ascribed the terms heavy and light to objective traffic levels (table 6.2). The selection of segments of video tape chosen to illustrate a steady increase in traffic flow through the intermediate categories up to the congested levels of flow, however, proved problematic. This was principally due to the patterns of traffic flow on tenemental radial routes generally, which is prone to platooning resulting from the operation of traffic lights outwith the street section depicted on the video.

Table 6.2 Individual Threshold Assessments

Respondent	Number of Vehicles in Video Excerpt when Traffic Flow ceases to be Light	Number of Vehicles in Video Excerpt when Traffic Flow becomes Heavy
Respondent 1, Female, aged 66	9	10
Respondent 2, Female, aged 84	12	9
Respondent 3, Female, aged 87	8	7
Respondent 4, Female, aged 67	5	7
Respondent 5, Male, aged 72	7	12
Respondent 6, Male, aged 69	6	7
Respondent 7, Male, aged 72	7	16
Respondent 8, Female, aged 80	1	12
Respondent 9, Male, aged 22	5	9
Respondent 10, Male, aged 23	4	10
Respondent 11, Male, aged 23	3	9
Respondent 12, Female, aged 22	6	10
Respondent 13, Male, aged 22	5	12
Respondent 14, Female, aged 23	4	8
Respondent 15, Child, aged 9	4	6
Respondent 16, Child, aged 9	5	4
Respondent 17, Child, aged 10	3	7
Respondent 18, Child, aged 10	8	12
Respondent 19, Child, aged 10	6	8
Respondent 20, Child, aged 10	9	12
Respondent 21, Child, aged 10	5	7

The results clearly indicate that flows are difficult to categorise (table 6.2). In three cases respondents stated that the point at which traffic "ceases to be light" as being at a higher level to the point at which traffic starts to "become heavy" (respondents 2, 3 and 16). More importantly, in reverse to expectation, the young adult age group perceived the point at which traffic levels ceased being light at lower levels overall (mean 4.5 vehicles; standard deviation 1.04 vehicles) compared to the elderly (mean 6.9 vehicles; standard deviation 3.18 vehicles) and children (mean 5.7 vehicles; standard deviation 2.14 vehicles) (table 6.3). The results, however, indicate a wider variation in the traffic flow level at the point when traffic flow ceases to be light amongst the elderly and child respondents. This indicates clearly that traffic flows are difficult to categorise.

Table 6.3 Point at which Traffic Flow ceases to be Light (Vehicles) by Age Group.

Age group	Maximum (Vehicles)	Minimum (Vehicles)	Mean (Vehicles)	Standard Deviation (Vehicles)
Elderly	**12**	**1**	**6.9**	**3.18**
Young adults	**6**	**4**	**4.5**	**1.04**
Children	**9**	**3**	**5.7**	**2.14**

Similarly, there were wide variations in the responses obtained from the elderly and children when indicating the point at which traffic becomes heavy (table 6.4). The variation in the assessment of traffic flow conditions is clearly affected by individual mobility and health levels. For young adults, the variation in the assessment of the point at which traffic becomes heavy is much lower (standard deviation 1.37 vehicles). This may reflect a greater homogeneity in terms of health, mobility and crossing strategy amongst this group. The wider variations associated with the assessment of traffic conditions by the elderly and children may be linked to a lack of understanding of what was required, even though this was explained in some detail at the time of the interview. This part of the interview may have proved too abstract for some respondents to grasp. Responses in other sections of the interview, especially from the elderly age group, where responses in relation to crossing behaviour and perceptions of safety and risk were clearly based on experience, were of much higher quality. The variation in these responses clearly does not invalidate the questionnaire responses (reported in chapter 5) and other results obtained from the in-depth interviews on perceptions of traffic flow. The results do indicate though that where there is platooning of traffic flow within a given time period, pedestrian perceptions cannot be translated into clear categories.

Table 6.4 Point at which Traffic Flow becomes Heavy (Vehicles) by Age Group.

Age Group	Maximum (vehicles)	Minimum (vehicles)	Mean (vehicles)	Standard Deviation (vehicles)
Elderly	16	7	10.0	3.2
Young Adults	10	8	9.7	1.37
Children	12	4	8.0	3.0

6.4.2 Crossing the road

This section seeks to identify different crossing strategies and respondents perceptions of risk and safety. Five video tape excerpts were shown to individual respondents and were chosen to reflect varying levels of traffic flow experienced by pedestrians on Raeburn Place. For illustrative purposes, a photograph of the traffic conditions depicted in each video excerpt is provided.

Plate 6.1 Heavy Traffic Flow, Raeburn Place.

Excerpt 1 - Heavy Traffic Flow (6-9 vehicles per 15 seconds)

A common crossing strategy adopted by the elderly in response to heavy traffic flow conditions was the use of pedestrian crossing facilities. This response was however tempered by the convenience of the crossing location. Respondent 1 (female, aged 66), who suffered from arthritis, indicated that if she was near a crossing she would cross at this location. However, she also stated that if she was not near the pedestrian crossing she would wait for a reduction in the traffic level before she would consider crossing.

> Question: After watching that video tape, would you tell me what you would do in these traffic conditions ?
>
> Answer: "Well I would wait if I wasn't near lights or that I would wait until the traffic sort of quietened down before I would attempt to cross

because I would be afraid if something was coming the other way and I would be knocked down. I would not say that I would decide to cross. I'd wait until it was quieter before I would decide to cross I'd maybe walk along the road a bit further before I would cross if I'd seen a lot of cars like that coming."

She indicated that in these traffic conditions if she was near a crossing facility she would cross at the facility, a convenient pedestrian crossing facility was clearly seen as essential by those with mobility problems. This was clearly because distances walked could be minimised.

Question: Would you walk along to the Pelican crossing at the end do you think?

Answer: "If I was near a Pelican crossing I would walk to the nearest set of lights no matter what road I was on if I was going to cross I'd cross at the lights".

However, when she was prompted with regard to choosing a crossing location she became quite agitated and indicated that on these sorts of roads she always crossed at pelican crossing facilities or at light controlled junctions.

Question: Is there a particular point where you would cross?

Answer: "As I said I don't cross when I see a lot of cars like that I'd either walk to one set of lights and if I could not cross there I would go up to the other set of lights".

For important journeys, or where a choice in making a journey was involved, she also indicated that she would always use the lights. If there was a choice whether or not to make a pedestrian journey, she did indicate that she would be too afraid to cross the road.

This may reflect her personal experience of having been involved in a road accident as a pedestrian in the past.

Mobility problems were also highlighted by respondent 2 (female, aged 84) as an important consideration when crossing in heavy traffic flow conditions. Due to her fear of falling she indicated that she felt uneasy having to cross the road in such situations. This fear has been discussed earlier.

> Question: After watching the video tape would you tell me what you would do in these traffic conditions?
>
> Answer: "No I would not cross the road there, as I say I just imagine myself lying there with the traffic going over me."

Despite this fear however, and initial reaction to the heavy traffic flow depicted in the video excerpt she indicated when prompted that she would cross at pedestrian crossing facilities. Although convenience of the crossing location was highlighted as an important factor which affected her use of crossing facilities. Amongst the frailer members of the elderly group, this is associated with the need to minimise detours and the length of time spent walking.

> Question: Would you use the Pelican?
>
> Answer: "Yes but mind I don't always use the Pelican, it depends on where you are some places are alright and others are all wrong [inconvenient]."

However, her remarks still reflect the concern with the potential for an accident to occur at such locations. This response was also qualified by her indicating that pedestrian crossing facilities might be used only when traffic flow levels were lighter.

Question: Would you cross?

Answer: "Well if the traffic light at the green man I would go, but if say there was a lot [vehicles]. if say there were less than half a dozen I would go but one can do the damage that half a dozen can do but when there's a lot I would not go, because I think, I might be wrong, that one is trying to beat the other car. No I would not unless they were well away from each other, well away, one here and one there you know. If they were speeding I would not cross the road. If they were going normal I would."

Respondent 4 (female, aged 67) indicated that if the traffic conditions were as depicted in the video she would cross at the lights because of the sheer traffic volume.

Question: After watching the video tape would you tell me what you would do in these traffic conditions ? What would you do ?

Answer: "I would go to the lights because I thought there was an awful lot of traffic."

She also indicated that this behaviour, irrespective of the importance of the journey i.e. whether there was a choice to make the journey or not, would be adopted. She felt that the traffic conditions were not particularly intimidating and that this was principally due to the provision of pedestrian crossing facilities in Raeburn Place.

Question: Would this change given the importance of the Journey?

Answer: "No, I would make the effort if the traffic was like that. I'd feel alright in those conditions."

In cases where mobility handicaps were found to be more severe, respondents indicated that if the traffic flow was intimidating they would attempt to re-arrange their journey to a period during the day when it was not so busy. Both respondent 3 (female, aged 87), who suffered from arthritis in her hands and feet, and respondent 6 (male, aged 69), who was partially sighted, saw the traffic depicted in this video excerpt as intimidating.

> Question: What would you do in those conditions, would you cross?
>
> Answer: "Oh dear, Oh I doubt it, Oh dear no I'd never attempt to cross. I would need to go to a stop. I actually wait until I could go with somebody I would cross on my own. I think I would go earlier, I think you have got more of chance to cross" (respondent 3, female, aged 87).
>
> Question: What would you do in these conditions?
>
> Answer: "I would say the traffic is steady. I would be very hesitant in crossing in those conditions" (respondent 6, male, aged 69).
>
> Question: If you had a choice and you were planning a journey what would you do?
>
> Answer: "Yes, I would re-arrange my journey, but it would depend what you were going for. I mostly try and re-arrange my journeys so that I am going before or after the rush hour, when the traffic is not so busy" (respondent 6, male, aged 69).

Respondent 3 (female, aged 87) stated that the traffic made her feel frightened. This may reflect her age and frailty.

> Question: What feelings does the traffic in that street evoke for you?
>
> Answer: "It gets you down and I get a bit frightened especially when you know they are going fast."

Nonetheless, respondent 3 said that she would attempt to cross if she was accompanied by someone. Respondent 6 (male, aged 69), who was partially sighted but active, stated that the traffic depicted in the clip would not make him feel particularly threatened.

> Question: How would you feel?
>
> Answer: "It would not upset me unduly if there were a green man. I would not cross unless there was a green man. I would not feel particularly threatened by the traffic at any time."

Both interviewees indicated that if they had the opportunity they would re-arrange their journeys to a period during the day when it was not so busy. However if the journey were important, both indicated that they would be very determined to make it, especially if it were an appointment or there was a time element. Respondent 3 (female, aged 87) also indicated that she would re-arrange her journey to earlier in the day and cross at a crossing.

By comparison, respondent 5 (male, aged 72), who stated that he experienced no health or mobility problems, indicated that he would adopt a crossing strategy which involved not crossing at a pedestrian crossing facility if the traffic flow levels were heavy. This strategy clearly involved waiting for an appropriate gap in the traffic, although he did admit that this might take some time. Again however, the response indicated that if a pedestrian crossing facility was located conveniently this would be used.

> Question: What would you do in those traffic conditions?
>
> Answer: "If I were on my own, I'd stand probably if I am going across to the shops to get my newspaper or whatever here just behind the bus stop

I'd watch for the traffic and instead of walking right back to the crossing and hope that you'd get across. I could do it. I just take my time and wait for the gap."

The adoption of this strategy is clearly based on his assessment of the traffic conditions depicted in the video as "not too bad". His response also suggests that in such traffic conditions, the gaps in the traffic stream occurring from the operation of Pelican crossings, at either end of the street section, are used. However, he did indicate that if the traffic flow levels increased he would cross at a Pelican crossing.

Question: How would you describe those conditions there?

Answer: "Ah that's not too bad. Also I'd watch for the stop lights both ends. If the traffic was really heavy I would move to the Pelican."

Despite the adoption of what appears to be a flexible crossing strategy, he also indicated that if he had a choice to make the journey or not and the traffic conditions were heavy, he would re-arrange his journey, if his destination was not too far away, to a quieter time during the day or on a Wednesday. Wednesday, half day closing for the shops, was felt to be a much quieter day.

Question: If you had the choice whether or not to make that journey would you cross in these traffic conditions?

Answer: "I would re-arrange the journey, depending on how far I had to go. If it wasn't very far I'd say well there is no point in making an effort to get there now I'll wait for a quieter time. If there was no choice of actual definite day, I'd probably say I'll go on Wednesday which is the lighter day which is my choice."

A flexible crossing strategy based on opportunity is a key feature of the strategies adopted by young adults. This is primarily based on the selection of appropriate gaps in the traffic stream thereby avoiding delay and/or the use of pedestrian crossing facilities. Respondent 9 (male, aged 22) indicated that in heavy traffic conditions he would wait for a suitable gap in the traffic in both carriageways which would enable him to get across the road in one crossing movement. Failing this, he stated that he would wait in the middle for another appropriate gap.

> Question: How would you cross in these conditions?
>
> Answer: "I'd wait for a suitable gap, I would not have said that was particularly heavy there I wouldn't have said. I'd try and get across in one, if there was not a suitable gap, I would cross to the middle and then nip across. The road's wide enough there for you to stand in the middle for couple of seconds without being in too much danger".

This strategy, he felt would not be affected by the type of journey he was on. For journeys where there was a choice whether or not he made that journey, he felt that he would cross as he considered it was not "particularly dangerous".

> Question: If you had the choice whether or not to cross as part of the journey?
>
> Answer: "It is not a particularly dangerous situation from what I see so I would cross, it would not bother me about crossing. If I was in no rush to cross I would cross at the point I indicated to you earlier."

For important journeys, where a time constraint or appointment applied, the respondent indicated that he would cross the road in the same way or choose a Pelican crossing depending on which was more convenient. This approach to crossing the road, based on walking into traffic streams and waiting in the centre of the carriageway, is linked to perceptions of the street environment as non-threatening. This perception seemed to emanate from the volume of slow moving traffic. When asked about the feelings the street environment depicted in the video evoked, he replied:

> "A reasonably busy street, but not busy at this time. It does not seem excessively dangerous. The traffic is moving particularly slowly, I don't think it's particularly dangerous. I would feel fairly relaxed - no particular stress having to cross that road without using the crossing. I think the level of traffic activity promotes that experience."

Similarly, respondent 10 (male, aged 23) indicated that in the heavy traffic conditions depicted in the video he would also adopt a crossing strategy based on gap selection and the non-use of pedestrian crossing facilities. The respondent indicated that in many instances, this actually involved running across the carriageway. When asked how he would cross the road in heavy traffic conditions he indicated that:

> "In those traffic conditions, I think I probably would cross the road at any point because the traffic, although it was not light, it did not seem very heavy and there was quite large gaps between cars. I think I would find a space between parked cars. I think I would run in those circumstances."

Clearly, this strategy is associated with the good health and relatively high levels of mobility.

As with respondent 9, respondent 10 indicated that this crossing strategy was associated with the perception of low levels of danger. When asked about his feelings evoked by the video excerpt of heavy traffic conditions, he replied:

> "It seemed quite a constant stream of traffic although I know there are not too many parked cars which gives you a safer feeling. If I had to make the journey, I would not feel in too much danger. If it was an important journey I would cross the road. Also, if there were time limits, I would ignore the traffic and just cross."

However, he did indicate that where there was a choice whether or not to make the journey and cross the road, he would re-arrange his journey, although if there was a Pelican crossing nearby this would encourage him to cross the road.

> "If I was planning a journey I don't think I would cross the road. I think I would re-arrange the journey. If there was not a gap I would use the crossing actually the Pelican would stop me re-arranging the journey. If the journey was important I would cross take a chance if there was a crossing near I would use that."

This type of crossing strategy was found to be commonplace amongst other members of the young adult age group. For example, respondent 11 (male, aged 23), respondent 12 (female, aged 22) and respondent 13 (male, aged 23) all selected a crossing strategy based on the selection of gaps in the traffic stream in which to cross. This is also based on confidence and the existence of no mobility handicaps, resulting relatively good health. When asked how they would cross in the heavy traffic conditions as depicted on the video, the respondents explained:

> "That's light, crossing there would be simple" (respondent 11, male, aged 23).

"I wouldn't say that the traffic was particularly heavy so it would be quite straight forward crossing the road. I'd just walk across normally" (respondent 12, female, aged 22).

"I'd cross through the gap and wait on the other side. I'd use the pedestrian crossing if I was heading that way. If I was going to a shop on the other side of the road I would just cross there" (respondent 13, male, aged 23).

Comments from these interviewees also indicated that their crossing strategy would not change given the importance of the journey. This was reflected in their responses about their feelings as pedestrians in the street when the traffic conditions were like those depicted in the video. For example, respondent 12 indicated that she would be "quite relaxed, calm, I wouldn't be anxious crossing the road. There is not a particularly large build up of cars".

The crossing strategies of the children were in sharp contrast to those of the young adults, and closely resemble the characteristics of crossing behaviours employed by the elderly in heavy traffic conditions. All the children indicated that crossing at a Pelican or light controlled junction was considered essential in heavy traffic conditions. Children interviewed in the study however, found it hard to articulate their feelings concerning the traffic.

Respondent 15 (child, aged 9) indicated that she would consider crossing at a Pelican even if this involved a detour off her planned route.

Question: What would you do if you had to cross there?

Answer: "If I really had to get to the other side, I'd have to walk all the way up to the green man. I'd rather do more walking and if somebody was waiting for me on the other side I'd rather be late than not get there at all."

She also indicated that she would re-arrange her trip to a less busier time during the day, if there were no time constraints and if the conditions were as bad as those in the video.

Question: Would you re-arrange your journey ?

Answer: "If there was a less busier time, yes I would then. If there was a really important journey I'd probably definitely cross at the lights. If I did not have to be there at a specific time, I'd pick a less busier time."

However, she could not describe her feelings evoked by the video excerpt, this was a common problem amongst this age group.

Similarly, respondent 19 (female, aged 10) felt that the traffic conditions in the video were busy and that in such circumstances she would also cross at the Pelican crossing provided. She also indicated that she would not re-arrange her pedestrian journey as a result of the traffic level.

Question: What would you do? Would you cross?

Answer: "No it's a bit busy. I'd go to the green man. I'd probably go on the journey then."

When asked about her feelings as a result of the traffic conditions she indicated that she would feel worried:

"It's starting to get heavy. I'd be worried because it is really quite busy there are a lot of cars going at quite a high speed."

Crossing facilities are clearly important in enabling children to cross roads in perceived safety. In heavy traffic conditions, respondent 21 (male, aged 10) indicated that he would also try to find the nearest traffic light. His response also indicated his strength of feeling with regard to their provision, reflecting his reliance on pedestrian crossing facilities when he is out walking. He indicated that if he could not find a crossing facility, he would go home.

> Question: What would you do in those conditions there?
>
> Answer: "I'd try to find the nearest traffic light, that's all really and if there wasn't one, I would just go back home."

He also indicated that on important journeys he would have to find a crossing. This may reflect a concern that crossing elsewhere in such heavy traffic would also result in delays; something to be avoided on an important journey where time constraints exist.

By comparison, where there was a choice about whether or not the journey had to be made in heavy traffic conditions, he explained that he would re-arrange his journey to another time.

> "If I had the choice I would not cross, I would try and re-arrange my journey to another time. I have done that quite often. When I have to get to some shops I think if I am going to that shop, I won't bother unless there any traffic lights near by".

Clearly, where there was an option to make a journey and the traffic conditions were seen to be heavy, child pedestrian trips were rescheduled.

The concern with finding a formal crossing facility to get across the road in heavy traffic conditions clearly reflects his feelings about the traffic. In the interview, he indicated that he felt worried and annoyed about having to cross the road in these heavy traffic conditions. When asked about the feelings the video excerpt evoked, he replied:

> "It's, well hard to explain really, I would feel worried and also quite annoyed that all these cars are being built and that all this pollution is coming. I would not really feel nervous, just annoyed that I would have to cross it."

Plate 6.2 Congested Traffic Flow in Both Carriageways, Raeburn Place.

Excerpt 2 - Congested Traffic Flow in Both Carriageways, Traffic stationary (over 9 vehicles per 15 seconds)

In congested traffic conditions, there is clearly a reliance on formal crossing facilities amongst the elderly, even if this involved a detour. For those elderly who are more frail, there is still a concern that when they are crossing at a Pelican crossing they will not have enough time to get to the other side in safety. For those elderly in good health and who experience few mobility constraints, evidence suggests that their crossing activity is not constrained to formal crossing facilities.

Respondent 1 (female, aged 66) stated that in congested traffic conditions she would always cross at the traffic lights. If this involved a detour, even on an important journey with a time constraint, she indicated that she would rather be slightly late.

> Question: Would you cross in these conditions?
>
> Answer: "Unless I was near lights it would not matter if they were stopping to let that car out. As they are in the video I still would not cross. I'd rather walk along to the lights and be two or three minutes late if I had an important appointment than cross the road."

When asked about how she thought her behaviour had changed from the last excerpt (which depicted heavy traffic conditions), she stated that she was now more cautious, especially after falling recently.

> "Oh, when I was younger I would have skipped across the road without bothering, but I think I am more cautious on the road now after falling in the middle of the road when there was buses and that coming you know. I think I am more aware of the traffic than I used to be".

Combined with an earlier experience (she had also indicated her involvement in an accident as a pedestrian some time ago), it is clear that these personal experiences were a major influence on her crossing behaviour and feelings about crossing. When asked about her feelings with regard to the congested level of traffic depicted in the video, she indicated that she felt "quite uptight". This concern with crossing the road clearly reflects her level of health and mobility. It was apparent from earlier in the interview that this had a profound effect on her travel patterns and crossing behaviour, although from her interview, there was no evidence to suggest that she would reschedule her journeys.

Similarly, respondent 2 (female, aged 84), on seeing the video excerpt of congested traffic conditions on both carriageways, indicated that she would not cross due to the high level of traffic.

> "No I would not cross the road in all that traffic. There are too many cars there, I would not cross the road. When they are like that you are asking for trouble."

She explained that she would be scared to cross the road when it was congested in both carriageways because she was not sure if the traffic would start to move off when she was trying to start to cross the road. This concern reflects the respondent's own limitations with regard to her health and mobility. When asked to describe her feelings about the traffic conditions in the video, she had indicated that she was worried about falling in the carriageway. This was particularly so when she felt that she had to rush across the carriageway. She explained:

> "I would be scared to cross in conditions like that, because they are not always standing like that you know. they are going all the time and you get some of them that won't slow down for you."

Concern with levels of individual mobility and the effect that this had on the ability to cross the road in congested traffic conditions, when the opportunity arose, was also reflected in the interview undertaken with respondent 3 (female, aged 87) who suffered from arthritis in her hands and feet. When she was asked about what she would do in these traffic conditions, she indicated that if she was to cross at a location other than at a crossing, she would have to be accompanied across the road. She stated that this was often the case if the Pelican crossing was not at a location near to her destination on the other side of the street. However, she felt that she could cross at a Pelican crossing on her own, this was clearly her preferred crossing location.

Question: What would you do in those conditions?

Answer: "Oh dear I would need to have somebody to take me across. That would be it for me. At a Pelican crossing it would be alright."

Respondent 3 also indicated that in congested traffic conditions she felt tense and upset: "It makes me feel upset, I get very tense...It's just the traffic, nothing else you know." This reflected her concern with crossing the road and her reliance upon others for assistance when crossing the road in situations where a Pelican crossing was not convenient.

Respondent 4 (female, aged 67), who also suffered from walking difficulties due to her health, also indicated that in congested traffic conditions, she would use the Pelican crossing. However, she indicated that this strategy would only be adopted if her journey was an important one. She felt that if the journey was not very important and if her shopping could be done on the one-side of the street, she would not bother to cross due to the traffic conditions. She also felt that she might even consider returning home to avoid the traffic. When asked what she would do about crossing the road she replied:

"Very busy, definitely cross at a crossing, I might even change my mind and go back home. Very, very busy, I would not consider using the Pelican

> in this if it was not very important. If there was any shopping, I could get on this side of the street, I would not cross."

In these congested traffic conditions, she felt that she would be much more careful than if she had to cross in comparatively lighter traffic. This is clearly reflected in her feelings about the congested traffic conditions depicted in the video excerpt. In the interview, she indicated that she felt overwhelmed by the level of congested traffic. However, she stated that this feeling could be pushed to the back of her mind if she did have to cross the road on an important journey:

> "Mmm I can't get the right word.. a bit overwhelming, It is very congested. If it was really a very important journey, I'd put these feelings to the back of my mind and cross at the crossing. If it was important and I did not have any option, I would go."

Similarly, respondent 6 (male, aged 69), who was partially sighted, indicated that he would "stick" to the pavement and that he would only cross at a Pelican crossing, in congested traffic conditions.

> "I would stick to the pavement, oh yes definitely. I would describe it as pretty heavy. I would only cross at a Pelican crossing, I would not dream of doing it otherwise in conditions like that."

Due to the congested traffic conditions he indicated that he would try and re-arrange unimportant journeys. This reflects a concern with trying to avoid the need to rely on other road users in this situation i.e. stopping at Pelican crossings in these traffic conditions. When asked how he thought his behaviour had changed from the previous video excerpt which had depicted heavy traffic conditions, he answered:

"I don't like to rely on other people. I don't like to cross in front of a driver unless there is a green man because it is putting the onus on him. If it wasn't important I would re-arrange my journey."

This concern with other road users in such congested traffic conditions was reflected in his feelings about the congested traffic conditions. Again he indicated he would always cross at the green man because crossing elsewhere places too much of an onus on others.

"As I say I would not feel particularly threatened. I would stick to the pavement. I would not be tempted, unless there was a green man. If I desperately had to, I'd take a chance, although it's not fair on other people when you are taking a chance."

Respondent 5 (male, aged 72), who stated he experienced no health problems and was still active, indicated that he would cross at the Pelican crossing, although there is evidence which suggests that he would try to cross at another location if the opportunity arose. Clearly, relatively good health and mobility can encourage flexible crossing strategies.

Question: What would you do in those traffic conditions?

Answer: "No, not exactly at the moment, while this lot is coming along. No I would not attempt it there. I'd probably go to the crossing."

On important journeys, a journey he had to make, he stated he would go to a Pelican crossing. However, if he did have a choice whether or not to make the journey he indicated that he would re-arrange his journey to a time period when the traffic was not so busy.

Question: If you are planning a journey which you had to make, what would you do?

Answer: "I would still go to the Pelican. If I had a choice, I would re-arrange the time of my journey but if I had no choice, I would have to go to the crossing."

This was reflected in his feelings about the congested traffic conditions in the video excerpt where the reliance on the Pelican crossing was an important issue. It was clear that the use of formal pedestrian crossing facilities was seen as a way of combating his frustration about trying to cross the road. When prompted about his feelings, he indicated his frustration with the levels of road traffic.

Question: How would you feel about the traffic conditions compared to the last clip?

Answer: "It's reasonably busy, mmm...fairly busy, but as I said I have seen it busier where the prospect of crossing I would give it a miss, I would go back to the Pelican across there."

Question: How would you describe your feelings?

Answer: "Frustration, yes frustration. The road traffic. I understand that people have got cars and they use them, but what can we do about it?"

Similarly, respondent 7 (male, aged 72), who indicated that he had no health problems, stated he would attempt to cross into the gaps between stationary vehicles in the traffic streams. However, when the traffic is moving he did indicate that he would cross at the nearest crossing.

Question: After watching the video tape, would you tell me what you would do in these traffic conditions?

Answer: "Sometimes I get between the cars, when it's slow like that. If it's slow like that I just wait for an opportunity. I dare say it's dangerous. Sometimes I have waited in the middle but sometimes it's dangerous. I admit I have done this. If it's too busy at times I do walk down and get the lights or walk back to the pedestrian crossing. If I wanted to get to the other side I would take the nearest crossing."

The use of pedestrian crossing facilities was also a key feature of child pedestrian behaviour in congested traffic conditions. Although respondent 15 (female, aged 9) indicated that in the congested traffic conditions she might be tempted to try and cross into the gaps between the vehicles, she also stated that she would consider making a detour to a crossing facility if one was nearby. When asked what she would do in these traffic conditions, she replied:

"That's very heavy. If I was to try to get to the bus stop, I would cross when there is a gap because they are quite slow moving. But I might also walk up to the Pelican crossing."

Questions regarding the importance of her journey and whether she would re-arrange her journey because of the traffic conditions were not answered. She did not really know how to articulate her feelings and was unsure of how she felt, although she indicated that she would rather be accompanied by a friend, if she crossed in these traffic conditions.

Question: How would you feel there in those traffic conditions?

Answer: "Maybe not panicky but I would rather be with a friend if I crossed that. I don't know how to describe it, I can't think of a word to describe how I feel, it's quite hard."

Respondent 19 (female, aged 10) also stated that she would cross at the Pelican crossing when the traffic was congested in both carriageways. When asked what she would do, she answered:

> "I would decide not to cross, it is really busy and I would decide not to cross, because there are a lot of cars. I might cross at the Pelican."

In these conditions she stated that she would only consider re-arranging her journey if it was unimportant or optional. This was reflected in her concern for her own safety. She felt she would not know when to cross and indicated that her feelings of apprehension had intensified in comparison with her feelings about the previous video excerpt, which had shown heavy traffic flow levels. When asked about her feelings she replied:

> "I'd feel a bit worried because you don't know when to cross."

Feelings of anxiety to do with the "unsafe" crossing conditions were also expressed by respondent 21 (male, aged 10). He indicated that he would get bored waiting to cross in these traffic conditions and would probably try to find a Pelican crossing.

> Question: What would you do? Would you cross?
>
> Answer: "Get bored waiting or find traffic lights. There is a lot more slow traffic."

In congested traffic conditions, most of the young adult respondents who were interviewed indicated that their crossing behaviour would be based on the opportunities provided by the slow moving traffic. This clearly reflects a higher level of mobility and relatively few health problems experienced by this age group. Respondent 9 (male, aged 22) indicated that he would cross between the cars as they were moving slowly. This strategy was often associated with waiting in the middle of the road, which was seen as not being particularly dangerous in these traffic conditions where the traffic was either stationary or slow moving.

> Question: After watching the video tape, would you tell me what you would do in these traffic conditions?
>
> Answer: "That's fairly heavy traffic there, that's slow moving; it would be quite easy to cross between the cars there as they move along. There is no particular danger moving into the middle of the road there. I would definitely cross in those conditions because of the speed of the traffic. I would jog between cars. In these sort of conditions I don't think you would get a suitable break in the traffic."

He also indicated that in these traffic conditions there was little point in making the effort to move to a Pelican crossing.

> Question: Would you go to a Pelican?
>
> Answer: "Probably not because with the Pelican crossing there when it is used the traffic will come to a stop any way. I would not make any particular effort to move toward the crossing."

This confidence in his ability to select a gap of sufficient size in both congested carriageways was reflected in his response about how he thought his behaviour had changed. He indicated that unlike the video excerpt where traffic conditions were depicted as heavy, he felt that crossing was easier because the traffic was moving more slowly due to the increased volumes of traffic.

> Question: How do you think your behaviour has changed?

Answer: "I would say that it is easier to cross in this situation than in the last one, because the volume of the cars has increased. It is much easier to cross between cars which are moving slowly like that than to nip in front of slightly fast moving cars."

Journeys where an element of choice was involved helped to make the decision to cross more flexible. In such situations, he stated that he would walk along the pavement until he saw a break in the traffic. If a large enough gap did not appear, he indicated that he would continue to walk until he reached the pedestrian crossing.

Question: If you were planning a journey where you had the choice, would you cross in those conditions ?

Answer: "If I was walking along the street, it would depend if I were walking along and if there was a break I would cross. But if there was not a break I would carry on walking towards the crossing."

However, this crossing behaviour was found to change when the journey was an important one. On such journeys, the key was convenience. This was evident from the interview.

Question: If you were planning a journey which was essential, what would you do ?

Answer: "If I was in a hurry, I would cross at the most convenient point. That may or may not be at the crossing. I would consider stopping in the middle."

In the interview he indicated that this flexible crossing strategy reflected his relaxed feeling and attitude in congested traffic conditions where the traffic is slow moving.

Question: What feeling does that street traffic environment portray to you?

Answer: "A busy street, with heavy traffic flow. If it was built up with lorries and buses you might think again. With slow moving cars no problem. I'd be relaxed. I don't have problems crossing."

The adoption of this type of behaviour when the traffic is congested in both carriageways was also apparent from the interview with respondent 10 (male, aged 23). He indicated that if he was late or if the journey was important, his behaviour would be more aggressive in trying to get across the road. For trips where there was an element of choice, such as on recreational journeys, he indicated that he would go out of his way to cross at a Pelican crossing. Although if this involved a substantial detour he explained that he would try and cross the road elsewhere.

Question: What would you do?

Answer: "Again, if I was late or if the journey was important, I would cross the road and hope the cars would stop because they are moving so slowly. In my experience if you just nudge out they will wave you across. If it was a recreational journey, I would definitely go out of my way and find a crossing. There are a lot of cars and it is all quite intimidating. If it was an important journey and the pedestrian crossing took me out of the way of my route then I would just cross the road quite probably. If it was not very important I would walk up to the Pelican and just cross there. Time is important as well if you had just seen the Pelican crossing turn red then you know that if you get there you are going to be waiting a while. So I think I would probably cross somewhere else."

Despite stating that the congested traffic conditions depicted in the video intimidated him, he indicated that he would not consider re-arranging any of his journeys because of the congested traffic conditions. During the interview, these feelings of intimidation were replaced by feelings of frustration about the conditions for pedestrians on this type of roads generally, particularly during the rush hour.

> Question: What feelings, as a pedestrian, does that clip evoke for you?
>
> Answer: "In that clip the amount of cars it's quite intimidating. The amount of parked cars both moving and stationary is intimidating. It makes me feel oh no not again, there are so many roads in Edinburgh which seem to be sort of like that. You get accustomed to it but you get really sick of it in the rush hour and you've got to cross the road and it takes a lot of concentration and energy. Sometimes I feel as if not enough is being done for the pedestrian and that sometimes I feel that the car has got the right of way and the pedestrian does not have the right of way."

The selection of gaps in the traffic streams was identified by respondent 11 (male, aged 23) as an important element in his crossing behaviour when traffic was congested and either stationary or slow moving. This helped to avoid the use of formal pedestrian crossing facilities and the detours which were often associated with their use, unless located nearby. However, the respondent also indicated that he would be more cautious when crossing in these traffic conditions. When asked what he would do and whether he would cross in congested traffic conditions, he answered:

> "That's heavy. I'd have to be more cautious crossing then. I'd probably try and walk across but I would be more cautious. I would not move to the

formal crossing, I'd probably nip out and run. Using the parked car as a sort of shelter."

Respondent 12 (female, aged 22), however, felt that the traffic was too heavy to risk crossing anywhere else than at a formal pedestrian crossing facility. She indicated that she found crossing in congested traffic conditions stressful. When asked about her feelings she replied:

> "Go to the pedestrian crossing, it's very heavy. Earlier my feelings for crossing the road would be far more relaxed than this, but now there is a lot of traffic so you would have to watch. With it being much heavier, you sense the traffic a lot more. I wouldn't be scared but cautious you know."

Plate 6.3 Congested Traffic Flow in the Northbound Carriageway and Medium Traffic Flow in the Southbound Carriageway, Raeburn Place.

Excerpt 3 - Congested Traffic Flow in the Northbound Carriageway (over 9 vehicles per 15 seconds) and Medium Traffic Flow in the Southbound Carriageway (3-6 vehicles per 15 seconds).

Similar crossing strategies were found to be adopted by the elderly when only one carriageway was congested and when congestion was experienced in both carriageways. Strategies principally revolved around the need to cross at pelican crossings, although several of those interviewed admitted that they might be encouraged to cross the carriageway due to the large gaps in the carriageway experiencing medium flow conditions.

Respondent 1 (female, aged 66) and respondent 2 (female, aged 84), who both experienced health problems, indicated that even though there was relatively less traffic in one carriageway, they would only cross at the pedestrian crossing facilities. For example, respondent 1 (female, aged 66), when asked how she would cross, indicated that she would be prepared to make detours to the pedestrian crossing facilities provided. She explained:

> "I would not cross there either, no, for there are too many cars coming and there are too many cars on the other side to try and cross, although there is not much in that carriageway....I come off in the bus there [at the bus top] I will not cross to this corner I will walk forward to the lights or back to the lights at the beginning of the shops".

Other interviewees, however, indicated that they would attempt to cross the road because of the large gaps in the uncongested carriageway. Respondent 3 (female, aged 80), who suffered from arthritis in her hands and feet, indicated that she would have a go at crossing because of the gaps and lower levels of traffic in one of the carriageways. When asked whether she would cross the road, she answered:

> "It's slower [the traffic], I'd have a go at crossing there the gaps are larger there [gaps in nearside carriageway]."

Similarly, respondent 4 (female, aged 67) also admitted that she would attempt to cross at a location other than at a pedestrian crossing facility because of the large gaps appearing in one of carriageways. This, she felt, was due to the operation of the traffic lights or Pelican crossing. When asked whether she would cross, she responded:

> Answer: "I admit I have seen myself when it is not busy on the one side and they are stationary [the cars] on the other because of the crossing I have seen myself go across. But that is only because I know the lights are in my favour and the cars are stationary."

In these situations, she clearly felt more confident because she knew that the lights were in her favour. This was reflected in her feelings about the traffic conditions depicted in the video, which she thought were: "Quite comfortable, the cars were more or less stationary and there was nothing coming the other way".

The large gaps appearing in the traffic stream in the uncongested carriageway were also highlighted by respondent 5 (male, aged 72). He also indicated that he would consider crossing into the gaps in the uncongested carriageway, because he knew that further up the street the lights had stopped the traffic. He felt that this would dissuade him from crossing at the Pelican crossing.

> Question: What would you do there?

Answer: "Now there, I would cross where this fellow's crossing here [pointing to the video where there is a large gap in the traffic in one carriageway]. There is very little coming this way and I know the lights have stopped the traffic and they can't move anyway. I would consider not using the Pelican, no not in this case as there are very few cars here coming this way and the lights are against them here. I'd be careful, I'd watch that there and wait until this one was past and depending on how fast he was going, I'd take a chance and cross".

In response to a question about how he thought his behaviour had changed, he indicated that the principal reason for not moving to a pedestrian crossing facility was:

"The gap [in the uncongested carriageway], because of the gap, otherwise as I say I would have gone to the Pelican. Had the number of cars going that way been the same the number of cars coming this way I'd have gone to the crossing".

Despite the adoption of such a crossing strategy, respondent 5 (male, aged 72) still indicated that if the journey was not important and there was a choice whether or not to make that journey, he would re-arrange the journey to another time during the day. For important journeys, however, he indicated that he might get agitated if he was delayed when trying to cross the road. Although he explained that he would rather be late than take a chance trying to cross the road.

Question: Do you think your feelings would change depending on the importance of the journey?

Answer: "If it was an important journey and depending on the time element that I had to arrive at a place at a certain time, I'd begin to feel a bit agitated, saying when the hell am I going to get across the road because there is bus coming and if I miss that bus there is not another one for twenty minutes and I am going to be late for my destination. I'd rather, I'd hate to be late. I always leave on time not to be late, but I would rather be late for an appointment than take a chance and cross the road. Basically, as I say, it's not fair on other people when you are taking a chance your putting somebody else at risk".

Although the children noticed the large gap in the uncongested carriageway they were, by comparison, generally not encouraged to cross, unless at a formal crossing facility, although respondent 21 (male, aged 10) did indicate that he would cross into the gap if the opportunity arose:

> "If the traffic came to a standstill I would find a gap to go through or traffic lights."

Although he did admit that he would feel a bit worried about doing so:

> "The gap that was there makes it easier. I'm not sure what I would do. It would depend on what mood I was in. I would feel quite worried though."

Respondent 15 (female, aged 9) indicated that she would only cross at a Pelican crossing facility even though she noted that there was not as much traffic in one of the carriageways. This strategy she felt would be adopted whatever the type of journey. She explained:

> "Definitely with the green, this big bit and there is not as many cars coming, it's like there is a big fair or something and every one is going up

that way (pointing to the congested carriageway), it's like when the Highland Show is on, the traffic is just monstrous. I'd cross with a green man or if there isn't a green man I'd cross at the lights."

Similarly, respondent 19 (female child, aged 10) indicated that the gap in the carriageway would not encourage her to cross at a location other than at a formal crossing facility. She explained that she was keen to avoid becoming stranded in the middle of the road, although she did state that when she was with her parents, she would cross to the middle of the road.

Question: What would you do? Would you cross?

Answer: "No that gap does not help because there are a lot of cars coming at you and you would only get half way. You will be in the middle and get stranded. I only cross to the middle if I was with my mum and dad. Dad does it more often than my mum. I would probably cross at the lights."

She felt that in comparison to the previous video tape excerpt, which had depicted both carriageways as congested, the traffic conditions did not make her feel as worried:

"Mmm, I'd feel okay if I could get across at the crossing, I wouldn't feel as worried as the last clip."

All of the young adults interviewed indicated that they would cross into the gaps which were occurring in the uncongested carriageway and wait in the middle of the road for an appropriate gap to cross the congested carriageway. Respondent 9 (young adult male, aged 22) felt that there was plenty of opportunity in these traffic conditions to adopt such a crossing strategy. In these traffic conditions he indicated that his crossing strategy would not change, given the importance of the journey. When asked what he would do in these traffic conditions he replied:

> "No problem at all. Very light traffic coming towards the camera, heavy traffic very slow moving in the other carriageway. Plenty of opportunity to cross. There's reasonable gaps between the traffic coming toward the camera. I'd cross halfway and then move between cars in the farside carriageway. I'd wait for the gap in the first carriageway where there is a gap."

He also indicated that he felt relatively safe in such situations due to the low speeds involved.

> Question: What feelings does the clip evoke for you ?
>
> Answer: "Relative safety because of the lower speeds involved, no opportunity for cars to speed up."

Similarly, respondent 10 (male, aged 23) also indicated that he would cross into the gaps in the uncongested traffic stream and then between the stationary vehicles in the congested carriageway. This would not change given the importance of the journey.

> "I think I would be very much influenced by other people crossing the road [in the video excerpt] actually. I'd probably do what they were doing. When there was a gap for the cars coming on I would probably just cross and then go into the gap in the congested one."

He also indicated that he would not go out of his way to use a formal crossing facility unless it was on his route:

> "If it was out of my way no, but if it was on my route I probably would use the crossing point."

In the previous video excerpt, where traffic was seen to be congested in both carriageways, he indicated that for this excerpt he was not intimidated by the traffic and felt safer. When asked how he thought his behaviour had changed from the previous clip, he replied:

> "In the second clip, I was quite intimidated by all the cars, but in this clip the cars in the far lane were stationary so you sort of got the perception that if you got across this lane it would be clear. In that last clip, I felt safer, I would cross the road quite happily. I would not think twice about crossing the road in that situation on either trip whether it was important or whether it was just recreational."

These feelings of comparative safety were clearly promoted by the stationary vehicles in the congested carriageway and the large gaps between vehicles in the traffic stream in the uncongested carriageway. In response to questions about his feelings evoked by this video excerpt, he answered:

> "As a pedestrian, I would not feel intimidated at all in that situation. I would feel quite calm, quite confident that I could get across the road safely. The stationary cars in the far lane definitely and then the fact that there were no cars coming in the near lane."

Similar feelings were experienced by respondent 11 (male, aged 23) who stated that the traffic did not worry him:

"I would not worry so much, one side [carriageway] is solid and the other there is not much traffic."

He indicated that if he needed to he would cross to the centre of the road and wait for an opportunity to cross:

"There is not much traffic [in the uncongested carriageway] I would cross to the centre, check and then continue. The carriageway with no traffic would not bother me. I'd cross from the junction on the right hand side. I'm less concerned about the speed, and crossing the carriageway with no traffic."

Respondent 12 (female, aged 22) indicated that she would adopt a similar crossing strategy, which would involve crossing into the gap in the uncongested carriageway and then waiting in the middle for an appropriate gap in the other carriageway.

Question: What would you do?

Answer: "I would do what everyone else was doing in the clip cross to the middle of the road, see what the traffic is like and see if it was held up. I'd wait in the middle because the volume of traffic in one carriageway is so great so you would have to be careful. You would have to check that it had not started moving. The gap in the other carriageway would make crossing easier in that carriageway."

She felt that this strategy would not change given the importance of the journey. These traffic conditions were seen to be safer than those depicted in the previous excerpt, where both carriageways were found to be congested. She also felt that the traffic conditions would make her feel less stressful:

> "No, the importance of the journey would not be a great consideration. This would not change given the importance, getting across the road is quite easy. I'd just find a gap. My behaviour would be more relaxed the traffic is not as heavy as the previous clip."

Plate 6.4 Medium Traffic Flow, Raeburn Place.

Excerpt 4 Medium Traffic Flow (4-6 vehicles per 15 seconds)

Amongst the frailer members of the elderly group, crossing the road during periods of medium traffic flow was seen as problematic. Those elderly who were more mobile found these traffic conditions less so. Respondent 1 (female, aged 66), who experienced arthritis in her legs, indicated that she would make a detour, if required, in order to cross at a Pelican crossing. This is clearly linked to her lower levels of mobility. She also stated that she was frightened and afraid of the traffic particularly if she saw another pedestrian trying to cross. This fear and fear for others affected her deeply and is based on her own personal experience of being involved in an accident as a pedestrian:

> "No, I would not cross in those conditions as I say I would rather walk up to the lights...I would get very tense if I saw someone trying to cross between the traffic, I get very worried and afraid in case they are going to get knocked down."

Her anxieties about the traffic and crossing the road in these traffic conditions were compounded by the numbers of parked vehicles on the street:

> "I don't think so many cars should be allowed to park in a main street. Even kids run between parked cars and could be knocked down and killed, No, I am afraid I don't like parked cars."

Concerns about personal safety were also expressed by respondent 2 (female aged 84), who was constantly worried about falling when crossing the road. She indicated that in medium traffic conditions she would reschedule her journey and not cross the road, although she did indicate that if the journey was important and she felt that had plenty of time to get across the road, she would consider crossing. She indicated that she would be:

"Very worried, you make up your mind to go out and when you see the traffic, that's all you think about, the traffic, and you just say I'm going back home, I can't be bothered with that."

Other members of the elderly group who were more mobile and experienced less difficulty walking indicated that the traffic conditions were more favourable for those pedestrians wishing to cross the road. Respondent 4 (female, aged 67) stated that she felt the traffic was relatively "quiet" and that she would cross at an informal location. If she needed to, she stated that she would cross to the centre of the road and wait for the traffic in the second carriageway to pass, although she did indicate that she would use the pedestrian crossing facility if it was convenient for the shops she wanted to go to on the other side of the road.

"That's nice and quiet traffic that. I have seen myself cross when it is quiet like that. I would walk, I can't walk that quick anyway, if I saw traffic coming, I would stop in the middle of the road. I would consider using the crossing because the shop opposite is next to the crossing."

This crossing behaviour is clearly linked to her feeling more comfortable in the street due to the lower levels of traffic. When asked to describe her feelings, she indicated:

"I'd feel a lot more comfortable in the street because there was less traffic."

Similarly, respondent 5 (male, aged 72), who experienced no health or mobility problems, stated that the traffic conditions were "not too bad" to cross in to. When asked what he would do, whether he would cross or not, he stated:

"Now that's not too bad. I'd cross now just like this person [in the video]. I would not consider moving to the Pelican in that case."

He was clearly confident about crossing the road in these medium traffic conditions although he admitted that he would feel: "quite relieved having got away with it [crossing the road]."

The crossing behaviour adopted by children in medium traffic flow conditions was similar to those elderly who experienced few mobility constraints as pedestrians. Although the first choice in all cases was to cross at the Pelican crossing as this was seen to offer increased safety, a key feature of the responses was also the willingness to cross into gaps in the traffic as an alternative crossing strategy. Both these options would be used for important journeys and journeys where a choice about whether or not to make that journey was involved.

> "I'd cross at the lights, the gaps are quite big. If the lights were not working, I'd cross into a gap. I'd use the lights even though it is not that busy. If I were with my parents, they would probably take me and my brother across" (respondent 15, female, aged 9).

> "I'd may be cross like that man in the video, but I might go to the lights. It would be safer at the lights. If the lights are near, I'd go to the lights but if the traffic was like that I'd try to cross. I'd run through the cars" (respondent 19, female, aged 10).

> "I wouldn't cross there in that condition, there are cars coming at just about every time. If there were a gap, I would cross. I would try to use the

lights but if I had to wait a long time for them to change, I would wait for a gap" (respondent 21, male, aged 10).

These crossing behaviours were associated with relaxed feelings. None of the children interviewed were particularly anxious about the traffic flow levels depicted in the video excerpt.

Amongst the younger adult age group, crossing strategies using the gaps in the streams of traffic were in evidence, although some of the group stated that they would cross cautiously, the crossing strategies clearly reflected their relaxed feelings and attitudes. Respondent 12 (female, aged 22) indicated that she would cross into the gaps in the traffic stream, although this would not involve waiting in the centre. She explained that she would:

> "Probably do the same as the man in the clip crossing the road. I'd wait for a clear break and then run or walk quickly across. I wouldn't stop in the middle though. I'd cross into the large gap, because there are gaps at this time in both carriageways. It's quite a large gap so you could get across. The gaps would encourage me to cross. I wouldn't go to the crossing, I would probably wait for another gap. This wouldn't really change depending on the importance of the journey."

She indicated that this approach would be adopted for both important and optional journeys. However she did indicate that:

> "If there were a time limit and it was important, I might probably move to the crossing."

Compared to the previous video excerpt, where traffic had been congested in one of the carriageways, she felt that her behaviour had changed because she felt more relaxed in the lower traffic level. When asked how she felt, she replied:

> "It's become more relaxed, the traffic would not have as much effect on me as the last clip. I'd feel quite at ease, I wouldn't be flustered or anything. There isn't a build up of traffic."

Respondent 9 (male, aged 22) indicated that although he would be more cautious of the traffic than when the traffic was congested he indicated that he too would utilise the gaps in the traffic. When asked what he would do in these traffic conditions, he explained:

> "More cautious, the amount of traffic is less than the other one, more opportunity for higher speeds. I would cross in a similar way to the person in the film. A short jog across through a break or just walk along and if you see a break in the traffic take it or if not, go to the crossing. I would not hesitate if I had to cross and even if it wasn't very important I would cross. I would not wait in the middle because the speed is high. I would wait for a convenient break in the traffic, although I would move along to a crossing if there was not a suitable break in the traffic."

This cautiousness appears to be due to traffic speed which the respondent thought was relatively high. When asked how he thought his behaviour had changed from the previous clip, which had depicted congested traffic in one carriageway, he indicated:

> "The higher speed of the traffic, I would be more cautious not knowing how the cars are going to behave, less chance of them seeing you if they are going faster."

He indicated that this crossing behaviour would be adopted for both important and optional journeys.

Nonetheless, respondent 10 (male, aged 23) indicated that he would only consider crossing at a Pelican crossing because of the heavy traffic flow. This was associated with a build up of traffic behind a bus which had pulled out from a bus stop further along the street section. He indicated:

> "I think I would go to the pedestrian crossing. The bus created the image of quite heavy traffic. I was definitely put off crossing the road in that example and I would have gone up to the Pelican crossing no matter what my trip was, whereas in the third clip, I would have crossed the road no matter what my trip was."

He also indicated that he would cross at a Pelican crossing in these traffic conditions whatever the importance of the pedestrian journey. At these lower levels of flow, he felt that the traffic was moving quicker and that he did not feel safe.

Plate 6.5 Light Traffic Flow, Raeburn Place

Excerpt 5 Light Traffic Flow (0-3 vehicles per 15 seconds)

Apart from respondent 1 (female, aged 66), all the other members of the elderly age group indicated that the conditions for pedestrians crossing the road were extremely favourable. As a result, no evidence of the rescheduling of pedestrian crossing activity was recorded for the category of light traffic conditions. Respondent 1 however indicated that in light traffic flows, she would still use a pedestrian crossing facility. This was not surprising given her own personal experience of being involved in an accident as a pedestrian at a crossing facility. When providing her account of this experience, she admitted that "ever since I have been afraid of roads". As a result, she indicated that she would still cross at a Pelican crossing even if this involved a detour.

Respondent 2 (female, aged 84) indicated that she would cross in the traffic conditions depicted in the video without hesitation. This stated behaviour was associated with "feeling alright".

> Question: Would you decide to cross in these traffic conditions?
>
> Answer: "That's alright, I would cross there. I feel alright."

This was despite a fear of falling over in the carriageway due to her frailty and the feeling that drivers never gave her enough time to get across the carriageway. Similarly respondent 3 (female, aged 87), who suffered from mobility problems as a result of arthritis in her hands and feet, indicated that she would attempt to cross the road and not bother to use the Pelican crossing. When asked if she would cross the road, she stated:

> "That's alright, that would do me I would cross there, I wouldn't bother to use the Pelican. I feel alright now, I would attempt to cross."

Respondent 6 (male, aged 69) despite being partially sighted, indicated that because the traffic was so light and there were what appeared to be large gaps in the traffic streams, he would cross carefully. He also indicated that he would use the parked cars to narrow the carriageway width that he would have to cross.

> Question: Would you decide to cross in these traffic conditions?
>
> Answer: "Well I would probably walk across in that conditions. The road is obviously clear. I'd step out beside one of these parked cars and looking around fairly closely. They make the road narrower crossing over. They are usually of benefit when things are like that. But it would have to be like that before I would attempt to cross."

This type of response was common amongst the elderly age group. Similarly respondent 4 (female, aged 67), indicated that she would not use the crossing facility because she found the traffic conditions very easy to cross in. When asked whether she would decide to cross in the traffic conditions depicted in the video she stated:

> "I would not worry about using the Pelican. In that one the traffic seems exceptionally light and very easy to cross. I'd feel alright crossing."

This behaviour was clearly linked with the traffic levels in the video except and the fact that she clearly felt confident crossing in these conditions. Respondent 5 (male, aged 72) also commented on the "quiet" traffic levels and remarked that he would be able to cross the road with no problem as a result. When asked about whether he would decide to cross, he answered:

> "No problem. I don't know what day it is but it is a very quiet day. Very little parked cars and mobile traffic."

He also indicated that in these light traffic conditions, whatever the journey, he would cross the road and would not consider re-arranging the journey at all. This confidence is reflected in his feelings about the traffic depicted in the video. He remarked:

> "That, I'd feel I wish it could be like this every day. I'd think my goodness what's happened? It's so quiet. I mean, I would just think this one of my better days. It is a better time, I'm getting away with it no hassle. In the previous one [video excerpt of medium traffic flow levels] I think there was a lot of traffic. I would think, good lord, there is a bus coming I'm going to miss it, but of course they won't stop for you and I am going to have to trot along to the crossing and go back to the bus stop."

There was a mixed response from the children interviewed towards the light traffic conditions depicted in the video excerpt. Respondent 15 (female, aged 9) indicated that despite feeling confident she would rely on the crossing facilities whatever the journey purpose or importance, although when accompanied by her parents, evidence suggests that this strategy was not adopted. When asked what she would do in these traffic conditions, she replied:

> "That's quite quiet. My parents would make a parent's decision to cross, but I'd still use the lights if I were on my own, definitely."

This behaviour was not common however. Respondent 19 (female, aged 10) indicated that because she felt the traffic conditions were safe due to the low levels of traffic ("I'd feel safe because there are no cars coming"), she would cross without the aid of formal crossing facilities:

> "I'd cross there because it's not very busy. I wouldn't walk to the lights."

Similarly, respondent 21 (male, aged 10) indicated that because the traffic was "very light", he would not need to use a pedestrian crossing facility unless it was close by. When asked how he would cross, he answered:

> "That's very light, if there wasn't a crossing near I would cross. My behaviour would have changed [from the last video excerpt] quite a lot. I wouldn't walk quickly. If the lights were near, I would use them, if they were far, far away I wouldn't."

In these conditions, he clearly felt at ease. When asked how he would feel in these traffic conditions, he replied:

> "I would feel at ease, I wouldn't feel very nervous. I would feel nervous if there was a car coming."

Crossing behaviours exhibited by the young adult group in light traffic conditions also reflect a more relaxed feel about these traffic conditions. This level of traffic was seen to provide a more than adequate opportunity to cross. Respondent 9 (male, aged 22) saw the traffic as unthreatening. When asked whether he would cross in these traffic conditions, he answered:

> "I'd cross at any time, there is hardly any traffic movement and hardly any danger at all."

This was also reflected in a willingness to avoid re-arranging the journey to another period during the day. When asked how he would feel crossing in the light traffic conditions depicted in the video, he remarked:

> "Unthreatened, no problem crossing the road. No danger. No need to use the Pelican crossing. I'd feel calm."

The need not cross at a Pelican crossing was also highlighted by respondent 10 (male, aged 23). When he compared his feelings to when the traffic flow level in the previous video excerpt was medium, he indicated that he would not feel as intimidated:

> "I felt very safe and as though I could cross without any danger to myself, whereas in the last clip [medium traffic flow level] I felt quite intimidated and I would have definitely have used the Pelican crossing. Very safe, felt very safe, I did not feel that there was any danger there at all in crossing the road."

The feeling towards the traffic conditions were clearly promoted by the low levels of traffic in the video excerpt. When asked which aspects of street environment promoted this, he answered:

> "The fact that there was very little traffic indeed coming either carriageway."

In this interview, he also stated that these feelings would definitely not change given the importance of different journeys.

Similarly, respondent 12 (female, aged 22) indicated that she would be much more relaxed crossing because "there is not much traffic". Her stated crossing behaviour reflected this, when asked if she would decide to cross in these traffic conditions, she replied:

> "Just look to see if anything coming, it's not very busy at all, I might even cross between parked cars. I would not pick a particular point."

She also stated that this would not change due to the importance of her journey. It seems that a principal component of this could be the large gaps between the vehicles in the traffic streams. Respondent 11 (young adult male, aged 23) highlighted this, but also voiced some concern about the speed of the traffic. The only respondent to do so for this video excerpt.

> Question: Would you decide to cross in these traffic conditions?
>
> Answer: "That's light, no problem crossing there, the gaps are big. I would just cross the road. Although there is not much traffic I would be concerned about the traffic speed."

6.5 SUMMARY OF FINDINGS

Older peoples' health and walking difficulties

Health problems were confined to the elderly group of respondents. Amongst the younger members of the elderly group with health problems and related mobility handicaps, there was little evidence to suggest that this had a large impact on their mobility and independence. By comparison, amongst older members of the elderly group, walking was found to be more problematic. In these cases reliance on home help, friends and family was found to increase. Increased frailty amongst this age group was also associated with a fear of falling. Evidence also indicated that health problems are compounded by the perceived threat of traffic. This was found to lead to greater reliance on crossing facilities. Respondents also feared for their safety at crossing facilities. In the case of Pelicans, particular concern was expressed that drivers would not stop and would travel straight through the green man phase at the lights. They also felt that the green man phase was insufficient to permit crossing in safety.

Route choice and crossing main roads

Evidence from the interviews indicated that the location of crossing facilities on main roads is an important consideration on all these journeys, and that the provision of pedestrian crossing facilities is seen as important in mediating the perceived threat of traffic on these routes for all age groups. For the elderly, locations without a Pelican crossing, or light controlled crossing with a pedestrian phase, crossing the road was seen as problematic and threatening. Fear of crossing and having to rush across during periods of pedestrian precedence, resulted in the rescheduling of pedestrian crossing activity. Accompaniment was however seen to boost confidence and help guarantee a safer crossing.

Amongst young adults, there was less concern about the location of crossing facilities on their routes, although it was acknowledged that it was safer to cross at such locations. Route selection by this group was based on assumptions of traffic level and the directness of the route in relation to their destination. Routes, where traffic levels, were lower were often selected because this was found to be less stressful. However, where time constraints on the journey existed, directness of route became more important.

It was evident from listening to children that they are subject to parental constraints, due to perceptions of traffic danger encountered on routes to and from school generally. This concern with child pedestrian safety was reflected in lower levels of independence. Children were often accompanied by friends or parents. The children themselves were found to share their parents concern of crossing main roads. Typically, journeys as with the elderly, were based around the use of pedestrian crossing facilities.

Crossing minor roads

Responses about crossing side roads were mixed by comparison to those about crossing main roads. Some of the elderly respondents experienced difficulties on minor roads, while none of the young adults experienced any problems. Amongst the elderly, perceptions of safety on side roads were principally associated with traffic travelling through the lights, at junctions with main roads, when they indicated a pedestrian precedence phase, and the speed of traffic. Younger adults, by comparison, seemed to encounter few problems on side roads. Traffic was found to be light on these roads and consequently, respondents in this age group felt relaxed about crossing side roads. Similar responses were found amongst the children interviewed in the study. Frequent references were made to the lower traffic levels and the more relaxed approach to crossing the road in such situations.

Personal experiences of the elderly

Personal experience was found to be an important factor which affected the perceptions of safety held by the elderly group. It was evident that bad experiences can accentuate fear of crossing the road.

Rescheduling of pedestrian activity

Indications from the elderly group suggest that those with mobility related health problems were prone to reschedule their walking trips to avoid busier times during the day. Some rescheduling of activity was found amongst the younger adults as a result of adverse traffic conditions, although this appears to be on a much smaller scale than that associated with the elderly. None of the children interviewed indicated that they would reschedule their pedestrian activity to avoid heavy traffic. This probably reflects constraints resulting from the need to attend school during the week and parental restrictions resulting in little opportunity to reschedule activity.

Parked cars

Even though parked cars at the kerbside were identified as making it easier to cross the road, they were also highlighted as a particular street feature which caused problems for the elderly. Only one young adult interviewed found parked cars a problem. Parked cars presented a number of problems to pedestrians including causing obstructions on the pavement, making it harder to find a place to cross the road at the kerbside, and causing problems at bus stops - forcing buses to stop further away from the kerb thereby increasing feelings of insecurity.

Perceptions of traffic flow

Pedestrian perceptions of traffic levels could not be translated into clear categories, especially for intermediate flow categories. Individual assessments of traffic flow conditions indicated wide variations in the assessment of thresholds between traffic flow levels. This was found to result from the platooning of traffic flow and individual differences of respondents associated with health and mobility levels.

Unexpectedly, the data indicated that the young and elderly perceived the point at which traffic ceased to be light at higher levels than younger adults. While the point at which traffic became heavy was generally within an average range of 8-10 vehicles for all age groups, although for the elderly and young, larger variations in this assessment were recorded. This is related to health, mobility and confidence in crossing the road.

Perceptual data on crossing the road in five different situations, with markedly different traffic flow levels, highlighted the crossing strategies and behaviours adopted by different age groups. In all but the light traffic flow conditions (0-3 vehicles per 15 seconds) the use of pedestrian crossing facilities by the elderly was a key feature of both important and journeys where a choice whether or not to make the journey existed. In situations where traffic was found to be intimidating, respondents stated that they would reschedule their journeys although feelings were often ignored if the journey was considered important.

For those elderly respondents in good health and who experienced few mobility constraints, evidence suggests that their crossing activity is not constrained to formal crossing facilities. In medium traffic flow conditions (3-6 vehicles per 15 seconds), respondents stated that they would cross at informal locations, into the gaps between the vehicles in the oncoming traffic streams.

The crossing strategies adopted by children were found to resemble the crossing strategies employed by the elderly. All the children indicated that crossing at a Pelican or light controlled junction was essential in all but the light traffic flow conditions (0-3 vehicles per 15 seconds). As with the elderly, rescheduling was considered when the journey was thought to be unimportant and without time constraint. Children were also found to be anxious and worried about traffic conditions generally, although in medium traffic flow conditions (3-6 vehicles per 15 seconds) the first choice in all cases was to cross at the Pelican crossing, as this was considered the safest place to cross. A feature of the responses was the willingness to cross into the gaps in the traffic as an alternative crossing strategy.

Flexible crossing strategies were adopted predominantly by young adults in all traffic conditions. This was found to be based primarily on the selection of appropriate gaps in the traffic stream, thereby minimising delays and/or avoiding the use of pedestrian crossing facilities. This strategy was largely unaffected by journey importance. However, if gaps in the traffic were not forthcoming there was evidence that pedestrian crossing facilities would be used even if this involved a detour. This behaviour was found to be associated with the perception of traffic flow as non-threatening and of a low level of danger, a perception promoted by the volume of slow moving traffic. In medium traffic flow conditions (3-6 vehicles per 15 seconds), evidence indicates that young adults were more cautious crossing into gaps in the traffic due to the relatively higher traffic speeds. However, this age group generally displayed a relaxed feeling and attitude towards crossing in these conditions.

6.6 CONCLUSIONS

Evidence from the in-depth interviews complemented data from both the video and set-format questionnaire surveys. The open-ended questions, combined with the use of a specially edited video tape in the interviews, provided further insights into how people perceive objective traffic conditions and how this affects their decisions about crossing behaviour.

Pedestrian travel experiences were largely focused around crossing activity. Analysis of the interviews indicated that responses concerned with travel patterns were regularly interspersed with references to crossing strategies and the use of crossing facilities. For all age groups, especially the elderly, pedestrian crossing facilities were seen as an important component of route planning. Another feature characterising the pedestrian crossing experience was the fear that the traffic would ignore the pedestrian phase of lights. Personal experiences of accident involvement and "near misses" heightened this concern.

Fear of traffic conditions contributed to the rescheduling of activity away from periods during the day associated with high traffic levels. Other responses to heavy traffic flows also involved avoiding crossing roads. Traffic flow levels were also an important factor in determining the routes taken. Interviews with the children in this study highlighted the constraints which parents place on children due to perceptions of traffic danger.

Data also indicated that in different traffic conditions, different crossing behaviours and crossing strategies were chosen. Amongst the elderly, particularly those with health related mobility handicaps, reliance on crossing facilities in all but the light traffic conditions was a key feature. Children, were also more prepared to use crossing facilities, although if accompanied by an adult, they were more likely to cross at informal locations. The elderly and children in the study were more likely to be intimidated by all levels of traffic, apart from periods of light traffic flow levels. As a result, trips and activities to be undertaken on foot at busy periods during the day, where traffic flows were found to be intimidating, were avoided. Rescheduling and avoidance of crossing the road was a common strategy. Young adults, by comparison, were prepared to be more flexible in their crossing activity, choosing to adopt behaviours based on gap selection; often waiting in the middle of the road and the minimisation of delays while waiting to cross the road. Such strategies and behaviour were associated largely with lower levels of rescheduling and feelings of confidence.

CHAPTER 7 SUMMARY AND CONCLUSIONS

7.1 INTRODUCTION

This thesis has contributed new evidence to current discussions concerned with pedestrian provision in cities and the need for an enhanced understanding of the impacts of traffic on pedestrian behaviour. The concept of traffic barriers was highlighted as an important concept worthy of further consideration by policy makers when considering pedestrian behavioural change. The traffic barrier was defined in this thesis as:

> "the sum of inhibiting effects upon pedestrian behaviour resulting from the impact of traffic conditions within a specified environmental/street context. These effects can be either physical (observable) or psychological (unobservable) impediments to pedestrian movement.
>
> Variations in the extent to which the traffic barrier effect is experienced will be influenced by individual pedestrian characteristics (age, walking situation, personal experience) and trip characteristics (journey importance, trip type)."

This concept refers directly to the impact of traffic conditions within a specified street environment (context) and to perceptions of those conditions. The effect of the traffic barrier is manifested by observable behavioural response to those conditions, and within this, the importance of feedback or perceptions in terms of mediating behavioural outcomes is explicitly recognised. Traffic barriers were also considered in the context of the trade-off which exists between pedestrian mobility and safety, a trade-off which is directly influenced by the impact of traffic conditions on pedestrian crossing behaviour and their perceptions of the street.

The definition and discussion of traffic barriers was central to the aims of this thesis. The hypotheses tested in this study were:

1) The extent of the traffic barrier effect on pedestrian behaviour is determined by actual traffic flow levels.

This is broken down into sub-hypotheses.

Observed pedestrian behaviour associated with heavy traffic flow levels is characterised by:

i) longer pedestrian delays;

ii) shorter acceptance gaps;

iii) steeper crossing angles;

iv) longer total crossing times;

v) the elderly and young children experiencing the extent of the traffic barrier effect to a greater degree (as measured by i-iv above).

2) Traffic speeds are not a significant indicator of the barrier effect on central area urban roads where traffic speeds and the variation in speeds are low, and where high volumes of traffic and parking activity occur.

This is characterised by low levels of association between traffic speed levels, in both carriageways, with:

i) pedestrian delay;

ii) acceptance gaps;

iii) crossing angles; and

iv) total crossing time.

3) The traffic barrier effect is mediated by kerb side parking in the nearside carriageway for those in the adult age group.

This is characterised by:

i) the perception that crossing into gaps in the oncoming traffic stream is easier;

ii) increased feelings of security and safety;

iii) shorter pedestrian delays;

iv) shorter acceptance gaps;

v) shorter total crossing times.

4) The perception of traffic flow levels by different age groups affects pedestrian behaviour.

Perceived traffic barriers, determined by heavy traffic conditions and low levels of pedestrian amenity, are characterised by:

i) perceived poor conditions for pedestrians associated with predominantly traffic-related features of the street;

ii) low levels of perceived safety;

iii) the usage of formal crossing facilities rather than crossing anywhere; and

iv) the wish to take a different route when walking, as mediated by the route's attractiveness.

In addition to hypotheses testing, the in-depth interviews sought to identify other factors which influence pedestrian perceptions and behaviour. These factors could not have been foreseen and included in the design stage of the project.

The literature review, in chapter 2, highlighted the dearth of studies on pedestrian behaviour and safety which address the effects of changing traffic conditions on pedestrian behaviour, but indicated numerous implications from previous work for a study of traffic barriers. Video studies successfully focused on a number of behavioural measures, principally, pedestrian delay, acceptance gaps, and crossing angles, and enabled some assessment of the changes in pedestrian movement patterns. The use of the video enabled micro-level studies of traffic speed and flow at the time of crossing. The video studies were complemented by set format questionnaire surveys and in-depth interviews. Questionnaire surveys were used to evaluate perceptions of safety and crossing difficulty on these routes and identified factors, based largely on perceived traffic and street conditions, which influence pedestrian crossing activity and behaviour. Although the questionnaire analysis complemented the findings of the video study, they did not deal fully with the links between perceptions of traffic levels and perceived risk and behavioural response. Further work was undertaken using in-depth interviews to explore this link more fully and provide further insights into how people perceive traffic and how this affects their decisions about crossing.

7.2 PREVIOUS RESEARCH

The review of literature and discussion of policy and practice revealed that pedestrian crossing behaviour and the relationships between traffic conditions and the extent of barrier effects experienced by pedestrians, has been under researched. The main criticisms of policy and practice were that:

1) Despite a growing commitment by U.K practice towards the implementation of traffic calming schemes, traffic management and bus priority schemes, no criteria, techniques or methodologies had been developed to assess the likely effects of such schemes on pedestrian crossing behaviour and crossing movement. This was despite a commitment to give reasonable consideration to the needs of disabled people, pedestrians, and cyclists.

2) The lack of data and knowledge concerning the impact of changing traffic conditions on pedestrian behaviour had resulted in pedestrian delay being considered as a proxy for other aspects of the pedestrian environment, such as, intimidation and stress. Delay measures in isolation ignore the deterrence of road crossings and were therefore inadequate as measures of barrier effects.

3) There has been an over-reliance on the use of accident statistics to prove that a pedestrian safety problem exists, even though a road may be judged to be unsafe without high recorded levels of accidents. As a consequence, opportunities to improve conditions for pedestrians and reduce the traffic barrier effect were often missed in the decision-making process, which was geared towards the use of accident statistics for the identification of priorities for treatment.

4) The flow criteria, PV^2 - the criterion for the provision of pedestrian crossings as recommended by the Department of Transport, was inadequate. The criteria only included those pedestrians crossing and neglected those who were deterred from crossing and who experience the traffic barrier.

5) No formal working definition of the traffic barrier effect was mentioned in the literature. The Department of Transport's definition of severance, although a useful starting point, was problematic. Firstly, the definition is unnecessarily limiting by reference only to inhabitants and this undervalues the movement requirements of pedestrians. Secondly, physical and psychological factors were referred to in general terms, ignoring factors which needed to be specifically identified in order to characterise the very nature of barrier effects. Thirdly, it ignored trade-offs which exist between pedestrian mobility and safety.

Similarly, little research had addressed pedestrian behaviour modification in response to the traffic barrier effect. The literature review also revealed that:

1) There was insufficient, consistent historical data to permit the analysis of the impact of new crossing facilities in the before and after periods. The collection of adequate consistent data was also a problem associated with the development of predictive models of pedestrian activity.

2) Although modelling and studies of pedestrian crossing facilities highlighted the importance of retail land uses as trip generators, it had been suggested that models may have limited applicability in the central areas of cities, where a multitude of factors need to be considered in relation to the generation of pedestrian journeys. However, results from the Coventry study concluded that for suburban or district centres, pedestrian numbers may be easier to predict (City of Coventry, 1973).

3) Pedestrian crossing research had primarily focused on delays at random locations and at crossing facilities, yet theoretical simulations were found wanting. Assumptions used were found to ignore the fact that pedestrian and vehicle behaviour differs from one crossing situation to another. It has been concluded that the prediction of pedestrian mean delay and the percentage of pedestrians delayed depend primarily on the ability to model pedestrian crossing behaviour and the vehicle arrival distribution applicable to a particular site.

4) Studies of pedestrian crossing behaviour had focused directly on the age related differences of pedestrian crossing behaviour. Such studies though had not assessed the effect of changing traffic conditions on pedestrian movement and crossing behaviour, or the extent to which behaviour was modified, or suppressed, as a result.

5) Studies indicated, although not directly, that behaviour modification, as a result of the effect of changing or changed traffic conditions in a street, appeared to occur. For example, at sites where crossing was difficult, pedestrians were worried about safety and were discouraged by traffic. In particular, traffic levels and speeds were identified as being especially detrimental to the requirements of pedestrians. Where the intrusions by traffic are minimised, studies had shown that benefits arise in terms of an improved pedestrian environment, and increased levels of informal street activity and pedestrian activity. As traffic levels were reduced and speeds lowered, delays to pedestrians crossing were reduced; crossing angles became shallower; and crossing activity was more evenly distributed across the street. Other work suggested that crossing facilities encouraged pedestrians to cross a street; central islands, refuges, and road humps were found to be responsible for increases in concentration of crossing activity.

6) Attractiveness of such crossing facilities to pedestrians crossing a road may, in some circumstances, result in an increase in pedestrian casualties. The relationship between increased pedestrian activity and the number of pedestrian casualties is not a clear one however. It has been suggested that there is a trade-off between pedestrian mobility and safety. Namely, that as a consequence of the reduction in the barrier effect, through the introduction of traffic calming or central reservations for example, pedestrians may feel more secure and cross the road more frequently. Pedestrian casualties may not therefore decrease and could even increase, although a reduction in their severity would be expected.

7.2.1 Summary of the key issues

The key issues arising from these research findings, which are addressed in this thesis are:

1) Techniques are lacking by which the impact of traffic speed and flow on pedestrian crossing behaviour can be adequately assessed.

2) Only fragmentary evidence exists about the nature of pedestrian behaviour and activity modification in response to the traffic barrier effect or changing traffic conditions.

7.3 AN ASSESSMENT OF THE METHODOLOGY

The combination of methods has made possible a substantial contribution to pedestrian behavioural research. Previously, methodologies have been criticised on the grounds of fragmentation: that the study of pedestrian behaviour in isolation can never sufficiently increase understanding of the pedestrian mobility-safety trade-offs that are central to any understanding of the traffic barrier effect. A variety of techniques are needed, such as those reported in this study, which permit behavioural studies of the interactions between vehicles and pedestrians. In this study, a combination of video and questionnaire studies and in-depth personal interviews was employed to assess the impact of the traffic barrier effect on pedestrian behaviour and perceptions.

These techniques permitted analysis of behavioural responses to variations in traffic conditions throughout the day, and enabled traffic conditions to be assessed in relation to their impact on pedestrian crossing behaviour, with other aspects which may have an effect on behaviour held constant. This level of control would not have been possible in a before and after study due to changes arising from scheme implementation or over the time period involved. Similarly, comparisons with other streets would not provide the necessary level of control.

Previous research on pedestrian behaviour has made little use of video. The analysis of recorded video data proved to be extremely valuable to the study of the impact of traffic barriers on pedestrian behaviour, especially so in terms of incorporating responsive micro-level measures of traffic speed and flow at the time of crossing. Video was also seen to possess advantages over traditional manual methods, as discussed in chapter 3.

The disadvantages are the time consuming nature of data extraction from the video, as opposed to the on-street method, and the limits to the age categorisation of pedestrians, which is a judgement based solely on video image appearance. However, the use of video for behavioural studies has clear advantages in terms of data collection. It is acknowledged however that the time and cost constraints involved in the analysis of video tape may reduce the attractiveness and applicability of video methods for practice and research, where time and cost constraints are severe.

The questionnaire survey of perceptions associated with the traffic conditions and crossing the road provided a useful supplement to the video study. Responses, however, were lacking in several areas. Respondents were constrained to the set-format of the questionnaire; as a result the link between perceived traffic levels, behavioural response and perceptions of safety in relation to measurable objective traffic conditions were left unexplored. Respondents also found it hard to state what effect traffic speed had on them in terms of their perceptions of the street, and were unaware of time periods during which shifts in crossing activity occurred in response to adverse traffic conditions. In responding to questions about crossing behaviour and perceived safety levels, respondents may have over emphasised the stated "safe" behaviours adopted, rather than admitting to unsafe crossing strategies. Further work was therefore undertaken involving personal in-depth interviews across three age groups, combined with the use of a specially edited video tape, from which respondents' attitudes and perceptions were sought in relation to a set of five different traffic conditions depicted in separate video excerpts. The video provided the context in which the qualitative data obtained could be assessed.

Initially the study involved both resident and on-street questionnaire surveys, but the on-street survey was not repeated in the second stage of the study. This was due to the fact that responses from both the resident and on-street surveys were similar and because the resident survey guaranteed a higher level and quality of response. Hand delivery and collection of the resident questionnaire survey forms proved to be effective in achieving a good response rate and allowed the cost and time spent on the survey to be minimised.

It also provided opportunities for guidance to be given to those respondents who found the form difficult to fill in and enabled those who were interested in the project to seek further information. This also helped to ensure a higher level of response than might otherwise have been the case.

A recurring problem, in the questionnaire surveys, was the inability to obtain sufficient responses from the elderly and especially children. In the case of the elderly, this was rectified with a visit to a sheltered housing complex, where the organiser encouraged all residents to fill in a form. Several parents took forms for their children and stated that they had helped them to fill in the form, but this was not very satisfactory as child perceptions and responses may vary with parental presence.

The in-depth interviews, undertaken to further explore the link between the perception of traffic levels and perceived risk and behavioural response, identified additional factors which could enhance understanding of the function of traffic barriers. The sample selected for individual interviews helped to redress problems associated with the under-representation of the elderly and school children. However, problems were still encountered with the in-depth interviews of primary school children. Data from these interviews proved very limited in all but three cases. This can be explained by the trend towards increased levels of parental constraint, due to perceptions of traffic danger on routes to school and in residential environments, which restricts child pedestrian activity. This was evident amongst the children in the study. Their information and thoughts relating to the traffic environment did not appear to be well developed. Other factors were identified which might have affected the dynamics of these interviews in terms of the quality of response. These were the school room environment and the effect of having to deal with a complete stranger (the interviewer).

Problems encountered in the interviews with school children were also compounded by the unwillingness of the headmistress in the selected school to co-operate with providing the children for interviews. This created an uneasy situation. The support from administrators in the organisations where the interviews are scheduled to take place, is essential. By comparison and in stark contrast to the primary school children interviews, the interviews undertaken with the elderly had the full support and help from the day centre staff where the interviews took place.

The second section of the in-depth interview which consisted of a threshold assessment, where interviewees were played a specially edited video tape in which traffic flow was seen to gradually increase, also had some problems. The biggest problem, however, was to obtain intermediate flow levels which were not affected by platooning. For example, platooning can result in gaps in the traffic flow within a given 15 second excerpt of tape, even though traffic could be categorised as being heavy overall for that period. As a result, respondents often found the task of assessing the traffic flow thresholds problematic i.e. stating when traffic flow had "ceased to be light" and when traffic flow had "become heavy".

The in-depth interview design was also based on an innovative approach which combined the use of selected excerpts of video tape which were edited specifically to show different objective traffic conditions. This provided a context for the responses, a factor which was found to be lacking in the set format questionnaire surveys. The in-depth interviews successfully complemented the video studies of observable pedestrian behaviour and the set format questionnaire surveys by providing further insights into crossing strategies, route choice and perceptions of safety in different traffic conditions.

7.4 SUMMARY OF RESULTS

In seeking to gain a better understanding of the operation of the traffic barrier with a view to developing a number of operational measures, a number of hypotheses were tested in this study. The data obtained in this study has indicated that behavioural modification occurs in response to changes in traffic conditions, in a manner consistent with the concept of traffic barrier (tables 7.1-7.3). The behavioural analysis (chapter 4) has shown that the extent to which the traffic barrier is experienced by pedestrians on main central area urban streets, is determined primarily by traffic flow. Speed conditions at the time of crossing were found to have a lesser effect. Findings also indicated that reductions in the traffic barrier effect are experienced by those pedestrians who cross from behind parked vehicles.

Results from the analysis of the set format questionnaires (chapter 5) indicated that decisions relating to pedestrian travel generally, and more specifically crossing the road, are associated with perceptions of traffic conditions and traffic related environmental quality. Perceived heavy traffic flows led to the selection of formal crossing locations (e.g. Pelican crossings) and were associated with low levels of safety, high levels of crossing difficulty and low levels of pedestrian amenity. For all levels of traffic condition, the elderly and young stated that they would use Pelican crossings. These perceptions of crossing difficulty, during periods of heavy traffic flow, were consistent with the results from the pedestrian behaviour studies in Raeburn Place.

Data from the in-depth interviews (chapter 6) provided further insights into the travel experiences and impact of traffic on pedestrian crossing behaviour and complemented the video and set-format questionnaire studies. Results from these interviews clearly demonstrated that the impacts of the traffic barrier on pedestrian behaviour were wider than suggested by the video studies of observable behaviour. Decisions relating to route choice and activities such as shopping, are often made before embarking on a pedestrian journey. The qualitative data obtained indicated that the use of crossing facilities is an important feature of child and elderly pedestrian behaviour in all but light traffic conditions. Evidence also indicated that young adult pedestrians, due to relatively good health and mobility levels, were more flexible in their crossing strategies than other age groups.

Summaries of study findings are provided in this section and discussed with reference to the hypotheses set out earlier in this chapter (tables 7.1-7.3). The relevant hypotheses are numbered in the text in parentheses to enable referencing back. The results are discussed in the following order:

1) pedestrian movement and activity patterns;

2) pedestrian crossing behaviour and perceptions;

Table 7.1 Summary of Video Study Findings

Traffic Conditions[1]	Observed Pedestrian Crossing Behaviour
Heavy (6+ vehicles)	1) low % crossing behind parked vehicles 2) kerb delays over 20 seconds 3) walk across carriageway 4) crossing angles steep 5) acceptance gaps 0-15 seconds
Medium/Heavy (4-6 vehicles)	1) moderate % crossing behind parked vehicles 2) kerb delays over 15 seconds 3) walk across carriageway 4) crossing angles steep 5) acceptance gaps 0-15 seconds
Light/Medium (2-4 vehicles)	1) moderate % crossing behind parked vehicles 2) kerb delays 5-15 seconds 3) walk across carriageway 4) crossing angles less steep 5) acceptance gaps 10-20 seconds
Light (0-2 vehicles)	1) high % not crossing behind parked vehicle 2) kerb delays 0-10 seconds 3) run across carriageway 4) crossing angle less steep 5) acceptance gaps over 25 seconds

Note
[1] Traffic flow defined as that 15 seconds before crossing action started.

Table 7.2 Summary of Questionnaire Study Findings

Perceived Traffic Flow Level	Stated Pedestrian Responses
Heavy	1) unsafe 2) medium/high stress levels 3) medium/high risk levels 4) cross at pelican crossing 5) crossing very difficult 6) high levels of discouragement 7) high levels of deterrence 8) low levels of rescheduling 9) likely to change route 10 likely to change mode
Medium	1) unsafe 2) medium stress levels 3) medium/high risk levels 4) cross at pelican crossing 5) crossing difficult 6) medium levels of discouragement 7) low levels of deterrence 8) low levels of rescheduling 9) not likely to change route 10) not likely to change mode
Light	1) neither safe/unsafe 2) low stress levels 3) low risk levels 4) cross anywhere 5) crossing neither easy or difficult 6) low levels of discouragement 7) low levels of deterrence 8) low levels of rescheduling 9) not likely to change route 10) not likely to change mode

Table 7.3 Summary of In-depth Interview Findings

Traffic Flow Level	Stated Pedestrian Responses
Congested both carriageways, traffic stationary (over 9 vehicles per 15 seconds)	Use of crossing facilities by the elderly and children. Elderly in good health not constrained to using crossing facilities. Rescheduling of journeys by the elderly and children when journey considered unimportant. Feelings of frustration and anxiety with traffic levels shown by elderly and children. Young adults adopt flexible crossing strategies based on gap selection and delay minimisation. Young adults feel confident in these traffic levels.
Congested northbound carriageway (over 9 vehicles per 15 seconds), uncongested southbound carriageway experiencing medium traffic flow (4-6 vehicles per 15 seconds)	Use of crossing facilities by the elderly and children. Elderly encouraged to cross into the gaps in the uncongested carriageway. Children not encouraged to cross into the gaps in the uncongested carriageway. Young adults cross into gaps and prepared to wait in centre of carriageway for gaps in congested carriageway. Young adults flexible crossing strategy based on gap selection.
Heavy (6-9 vehicles per 15 seconds)	Use of crossing facilities by the elderly and children. Elderly and children found traffic intimidating. Elderly with no health problems tried to adopt flexible crossing strategy. If crossing nearby this was used. Rescheduling amongst the elderly if trip did not have to be made. Young adults adopted flexible crossing strategies although evidence of use of pedestrian crossing facility if no detour involved. Young adults unthreatened by traffic levels.
Medium (4-6 vehicles per 15 seconds)	Elderly with mobility problems and children use pedestrian crossing facilities. Elderly with no mobility problems encouraged to cross into gaps in traffic stream. Children despite first choice of crossing facility were willing to cross into gaps. Children felt relaxed about the traffic levels.
Light (0-3 vehicles per 15 seconds)	All age groups encouraged to use gaps in the traffic stream. All age groups felt relaxed about the traffic conditions.

7.4.1 Pedestrian movement and activity patterns

Walking on tenemental radial routes is an important activity and mode of transport. Most pedestrian trips along Bruntsfield Place and Raeburn Place are associated with essential activities, primarily these are: shopping; trips to/from work; trips to/from school/college. Only a small proportion of journeys are associated with inessential trips. Activity levels are particularly high for women, especially for those not in full employment or who have no car available. Traffic flows, in particular, are high, with 12 hour week day flows in the range of 13600-15600 vehicles passing through densely populated residential areas and areas with district retail functions.

Pedestrian activity on tenemental radial routes is mostly associated with adult pedestrians; by comparison, pedestrian activity levels associated with children and the elderly are relatively low. The initial morning period from 0800-0830 is dominated during the week by males aged 18-65 and is strongly associated with the journey to work/college. For females aged 18-65, pedestrian activity is greatest around midday and the early afternoon period, periods during the day which are associated with shopping, and lunchtime activities. The role and importance of walking for women is clearly linked to employment situation and car availability.

7.4.2 Pedestrian crossing behaviour and perceptions

Pedestrian delay

Total crossing times for all age groups were strongly dependent on kerb delay. A wide range of delays were experienced by pedestrians on both case study streets. Substantially larger delays were experienced by the young, elderly, and those accompanied. Traffic conditions, therefore, were particularly unfavourable to crossing activity for children and the elderly, who were unable to avoid relatively long delays at the kerb. For these groups, the reliance on pedestrian crossing facilities was of great importance in all but light traffic flow levels. This demonstrates that the traffic barrier is experienced, to a greater degree, by the elderly and children. This was found to be in line with the sub-hypothesis 1(v) which stated that the extent of the traffic barrier, as measured by delay and total crossing times, was experienced to a greater degree by these age groups. Further evidence confirmed this and indicated that flexible crossing strategies, based on the identification of appropriate gaps in the traffic stream and the minimisation of delay, were important features of pedestrian crossing behaviour associated with young adult pedestrians.

Other results confirmed the sub-hypothesis 1(i) which indicated that the extent of the traffic barrier, as characterised by pedestrian delay (and as a result, total crossing times confirming sub-hypothesis 1(iv)), is determined by actual traffic flow levels. Longer pedestrian delays were found to be related to heavy traffic flows, shorter acceptance gaps in the farside carriageway, and steeper crossing angles. Pedestrians clearly limited further increases in crossing time by adopting crossing strategies which incorporated steeper crossing angles into shorter acceptance gaps. Analysis did indicate however that pedestrian delay was principally affected by nearside carriageway traffic flow and, to a lesser extent, by farside traffic flow. Young and elderly pedestrians were found to be particularly affected by traffic flows in the nearside carriageway.

Traffic speeds, by comparison, had little effect and were negatively correlated: delays increasing as speeds fall, and also reflecting relationships with flow. On this type of street traffic flow is of prime importance in determining the level of the traffic barrier. These results confirmed the sub-hypothesis 2(i)(and 2(iv)), that traffic speeds are not a significant indicator of the barrier effect on central area urban roads where traffic speeds and the variation in speeds is low, and where high volumes of traffic and parking activity occur. This was reflected in the low level of association between traffic speed levels and pedestrian delay (and total crossing times) on these routes.

Acceptance gaps

Acceptance gaps (defined as the time of the gap between vehicles in which the pedestrian decides to cross) are principally associated with the traffic speed and flow relationship in each carriageway at the time of crossing: as traffic flows increase and speeds lower, acceptance gaps become smaller. For all age groups, traffic flow conditions have a significant impact on acceptance gaps, while speed and flow levels at the time of crossing, appear to have a greater impact on acceptance gaps for female pedestrians and those crossing accompanied. These results confirm the sub-hypothesis 1(ii) that acceptance gap size, as determined by actual traffic levels, is a factor which determines the extent of the traffic barrier.

Interviews also indicated that gaps in the oncoming traffic stream were an important element in the crossing strategies of young adult pedestrians in all traffic conditions. In situations where gaps were found to occur, originating from the operation of pedestrian crossing facilities, elderly pedestrians were encouraged to cross because they knew that the traffic had been stopped. Gaps relating to light traffic flow levels of 0-3 vehicles per 15 seconds were found to encourage pedestrians in the elderly group, with no mobility problems, and young adult age groups, to cross. Children, on the other hand, were rarely encouraged to cross. These findings complement the video study findings and confirm the sub-hypothesis 1(v) which indicates that the traffic barrier effect, as characterised by acceptance gaps, is experienced to a greater extent by children and the elderly. However, this may be further qualified by the suggestion that health and mobility constraints within the elderly group do differ.

Regression analysis confirmed that traffic flow makes a major contribution in determining pedestrian gap acceptance for both carriageways. The introduction of traffic speed into the regression equations produced a significant, but only small, increase in prediction for both carriageways. Results for the elderly suggest very little or no improvement in prediction with the introduction of traffic speed into the equations. This may reflect lower levels of perception and vision, associated with this age group. Whilst confirming the dominant impact of traffic flow on pedestrian behaviour, the findings also indicate that traffic does make some contribution to the traffic barrier in terms of acceptance gap size. This finding is a partial rejection of sub-hypothesis 2(ii) that traffic speeds are not a significant indicator. Traffic speeds clearly do make some contribution to the traffic barrier in terms of acceptance gap size, but in comparison to traffic flow this is small.

Crossing from behind parked vehicles

The majority of crossings were undertaken from behind parked vehicles. Pedestrians crossing from behind parked vehicles were found to cross at steeper angles. Evidence indicates that pedestrians crossing from behind parked vehicles experience reductions in the traffic barrier. A high proportion of crossings undertaken from behind parked vehicles were associated with heavy traffic flow levels, low speeds and shorter acceptance gaps in the nearside carriageway. This suggests that crossing from behind a parked vehicle is related to attempts by pedestrians to mediate the traffic barrier effect. This confirms the sub-hypothesis 3(iv) that the traffic barrier is mediated by kerbside parking in the nearside carriageway for the adult age group in terms of selection of shorter acceptance gaps. Further studies are needed, however, to clarify the extent to which the high proportion crossing from behind parked vehicles simply reflects the higher level of parking at higher flow level times. No evidence from the study confirmed the sub-hypotheses 3(iii) that crossing from behind a parked vehicle was associated with shorter pedestrian delays and 3(v) shorter total crossing times.

Although respondents in the questionnaire survey felt that crossing from behind a parked vehicle was perceived to make it easier to cross into gaps in the oncoming traffic stream, they felt that crossing from behind a parked vehicle did not increase feelings of security or safety and made it harder to see oncoming traffic. This evidence, whilst confirming sub-hypothesis 3(i) that crossing from behind parked vehicles for the adult age group is associated with the perception that crossing into gaps in the oncoming traffic stream is easier, also rejects sub-hypothesis 3(ii) that crossing from behind a parked vehicle is associated with feelings of security and safety. Results also indicated that those respondents aged under 18 and over 65 do not favour crossing from behind parked vehicles. Findings from the in-depth interviews also indicated that the elderly particularly found parked cars a problem. Factors which were found to promote feelings of insecurity amongst this age group were: causing obstructions on the pavement, making it harder to find a place to cross the road, and causing problems at bus stops by forcing buses to stop further away from the kerb increasing step height.

Crossing angles

Pedestrians were found to cross at steep angles generally, with even steeper crossing angles recorded for children, the elderly and for those who cross accompanied rather than those who cross alone. Steeper crossing angles are associated with increased kerb delay and nearside carriageway traffic flows, and reductions in farside carriageway traffic speed: all conditions associated with a relatively high traffic barrier. Clearly, steep crossing angles are taken to reduce exposure time in the carriageway, when the traffic barrier is high. This confirms sub-hypothesis 1(iii) that the extent of the traffic barrier on pedestrian behaviour is determined primarily by actual traffic flow levels as characterised by the pedestrian crossing angle. However, farside carriageway traffic speed was found to have a significant, but relatively weaker, impact on crossing angles. This is a rejection of sub-hypothesis 2(iii). Traffic speed may indeed be an indicator of the traffic barrier effect, as measured by crossing angles. The evidence also supports the sub-hypothesis 1(v) that children and the elderly experience the traffic barrier to a greater degree.

Crossing ratios

Crossing ratios were found to be low for both children and the elderly, reflecting a clear tendency for those age groups to move through the street sections and make less crossings at informal locations. Crossing ratios for the elderly and especially children were found to increase at a formal crossing facility. Even these ratios were still well below those for the adult age group. Evidence of a greater barrier effect on the elderly and the young, and trip deterrence when involved in crossing. This analysis only partially confirms the sub-hypothesis 4(iv) that the pedestrian behaviour of the elderly and children is associated with higher levels of usage of formal crossing facilities. Whilst this data highlights the extent to which children and the elderly experience the traffic barrier to a greater degree, it does not confirm sub-hypotheses 1(v) or 4(iv) outright due to the lack of any data which clearly highlights the links between crossing ratios and traffic flow level, both perceived and actual.

A limited analysis of crossing ratios by time of day revealed that shifts in crossing activity by trip type could be assessed. Linkages between traffic flow, parking density and the crossing ratio were not explored further in this study due to the unavailability of parking data for corresponding time periods.

Crossing ratios to sides of the street where more intensive retail activity is located were higher, indicating that the traffic barrier will be experienced to a greater degree by pedestrians on street sections where major pedestrian trip attractors are located. This was shown to be in line with crossing destination patterns.

Conditions for pedestrians

Questionnaire survey results for Bruntsfield Place and Raeburn Place showed that traffic conditions and crossing the road were seen as being particular problems for pedestrians. Other street features, such as pavement obstructions, parked cars, unloading and loading of vehicles, were seen as slight problems. Low levels of trip making activity are linked to respondents' perceptions of adverse conditions for pedestrians in the street. Large numbers of elderly who were found to make up to only 2 journeys a week, also found conditions worse than respondents in younger age groups. Car owners stated that conditions were more favourable for pedestrians than other respondents.

Perceived levels of safety

Bruntsfield Place and Raeburn Place are perceived as streets which possess pedestrian environments associated with high levels of stress and risk, and low levels of safety. These characteristics were also found to be associated with perceived heavy traffic flows on Bruntsfield Place, while for Raeburn Place, residents' descriptions of traffic flow as heavy were strongly associated with perceptions of bad conditions for pedestrians. This confirms sub-hypotheses 4(i) and 4(ii) that perceived traffic levels are clearly associated with poor conditions for pedestrians and low levels of safety.

Similarly, perceived traffic speeds were seen to have an adverse impact on the pedestrian environment in both streets, although respondents could not state what effect traffic speed had on them as pedestrians.

Evidence from the in-depth interviews indicated that health problems and related mobility handicaps had a profound effect on perceptions of safety. Health problems amongst the elderly were found to be compounded by the perceived threat of traffic. This was found to lead to greater reliance on crossing facilities. Respondents also feared for their safety at crossing facilities. In the case of Pelicans, particular concern was expressed that drivers would not stop and travel straight through the green man phase. They also felt that the green man phase was of insufficient duration to permit crossing in safety. This confirms the sub-hypothesis 4(iii) that the perception of traffic flow by different age groups affects pedestrian behaviour. This is characterised by the usage of pedestrian crossing facilities particularly amongst the elderly.

Personal experience was also found to be an important factor which affected the perceptions of safety held by the elderly group. It was evident that bad experiences can accentuate the fear of crossing the road. Accident involvement and the experience of almost being knocked down were highlighted by two respondents as having affected their pedestrian behaviour and perceptions of safety. This finding goes beyond the established hypotheses and suggests that decisions about crossing the road are not only concerned with actual and perceived traffic conditions.

Crossing minor roads

Responses about crossing side roads were mixed by comparison to those about crossing main roads. Some of the elderly respondents experienced difficulties on minor roads while younger adults, by comparison, seemed to encounter few problems on side roads. Traffic was found to be light on these roads and consequently, respondents in this age group felt relaxed about crossing side roads. Similar responses were found amongst the children interviewed in the study. Frequent references were made to the lower traffic levels and the more relaxed approach to crossing the road in these situations. This is in line with the sub-hypotheses 4(i) and 4(ii) that perceptions of traffic flow by different age groups affect pedestrian behaviour; where traffic levels were perceived to be at lower levels, a more relaxed approach to crossing the road was adopted.

Perceptions of traffic flow

Perceptions of traffic flow were found to have a major impact on pedestrian crossing behaviour. Findings from in-depth interviews, combined with the use of the specially edited video tape, confirmed the hypotheses 1 and 4 that the extent of the traffic barrier effect on the pedestrian behaviour of different age groups is determined by actual and perceived levels of traffic flow.

The extent of the impact of the traffic barrier was found to vary with age. In traffic flow conditions over 4 vehicles per 15 seconds (medium flow levels), a common crossing strategy adopted by the elderly and children was the use of pedestrian crossing facilities. This was seen as a way in which the impact of traffic flow could be mediated. The use of pedestrian crossing facilities by the elderly and children was a feature of both important journeys and journeys where the choice existed whether or not to make the journey. Crossing usage often involved detours and was found to be a key feature of route planning. This strategy was often associated with anxiety about crossing. In cases where the traffic was found to be intimidating, respondents indicated that they would try to reschedule their journey unless it was considered to be important. This confirms sub-hypothesis 4(iii). Although, where no health problems were found to exist, elderly respondents stated that they would try to adopt a more flexible crossing strategy especially when detours to crossing facilities could be avoided. For all levels of traffic flow however, if a pedestrian crossing facility was found to be located conveniently nearby, this would be used.

By comparison, young adults were found to select appropriate gaps in the traffic stream in all levels of traffic flow, thereby minimising delays and/or avoiding the use of pedestrian crossing facilities. This confirms sub-hypotheses 1(i) and 1(ii). This often involved being delayed in the centre of the road and was largely unaffected by journey importance. However, if gaps in the traffic were not forthcoming, there was evidence that the use of pedestrian crossing facilities would be considered, even if this involved a detour. This behaviour was found to be associated with the perception of traffic flow as non-threatening. A perception which was promoted more by the volume of slow moving traffic.

In light traffic flows (0-3 vehicles per 15 seconds) however, all age groups found conditions favourable for pedestrians. In these circumstances, most pedestrians stated that they would cross anywhere with no problems and no feelings of anxiety. This confirms sub-hypotheses 4(ii) that situations, where traffic barriers are at low levels or non-existent, are associated with low levels of traffic and high levels of perceived safety.

Data from the threshold assessment exercise indicated that pedestrian perceptions of traffic levels cannot be translated into clear categories, especially for intermediate categories. Analysis indicated wide variations in the assessment of thresholds resulting from the platooning of traffic flow and the individual differences of respondents due to health and mobility levels. Results from the interviews, in the context of crossing decisions in respect of specific traffic flow conditions, indicate that the elderly and young clearly perceive traffic flow to be at higher levels than the younger adults. This is related to health, mobility and confidence in crossing the road.

Deterrence, modal and route changes

Discouragement from undertaking certain activities; switching from walking to alternative modes of transport; changing route when walking; rescheduling of trips; and deterrence from crossing the road were all found to be strongly associated with heavy traffic flows, high levels of crossing difficulty, low levels of safety and low levels of pedestrian amenity. This confirms the sub-hypothesis 4(iv) that traffic barriers, resulting from heavy traffic conditions, are characterised by deterrence, route changes and the rescheduling of activity.

Indications from the elderly group suggest that those with mobility related health problems were prone to reschedule their walking trips to avoid busier times during the day. Some rescheduling of activity was found amongst younger adults as a result of adverse traffic conditions, although this appears to be on a much smaller scale than that associated with the elderly. None of the children interviewed indicated that they would reschedule their pedestrian activity to avoid heavy traffic. This probably reflects constraints resulting from the need to attend school during the week and parental restrictions that result in little opportunity to reschedule activity. This evidence provides further support for sub-hypothesis 4(iv) that perceived traffic flow levels by different age groups affect pedestrian behaviour.

Use of crossing facilities

Results, relating to the usage of formal crossing facilities, especially by the young and elderly, confirm the sub-hypothesis 4(iii) that the perception of traffic flow levels by different age groups affects pedestrian behaviour in terms of the usage of pedestrian crossing facilities. Respondents in the questionnaire surveys, on both streets, stated that perceived heavy traffic flow resulted in them changing their crossing location away from informal to more formal crossing facilities. Conversely, light traffic flow was associated with crossing anywhere. This corresponds with results obtained from the in-depth interviews. Results from the Raeburn Place survey also indicate that in all types of traffic condition, substantial proportions of respondents aged under 18 and over 65 crossed at Pelican crossings. Perceived low levels of pedestrian amenity, low levels of safety and high levels of crossing difficulty encouraged the use of formal crossing facilities, such as Pelican crossings.

Confirmation of the sub-hypothesis 4(iii) is further supported by evidence from the in-depth interviews which indicated that the location of crossing facilities on main roads is an important consideration on all these journeys. The provision of pedestrian crossing facilities is seen as important in mediating the perceived threat of traffic on these routes for all age groups. For the elderly, locations without a Pelican crossing or light controlled crossing, with a pedestrian phase, crossing the road was seen as problematic and threatening. Fear of crossing and having to rush across during periods of pedestrian precedence were associated by the elderly with the rescheduling of pedestrian crossing activity. Accompaniment was, however, seen to boost confidence and help guarantee a safer crossing.

Amongst young adults, there was less concern about the location of crossing facilities on their routes, although it was acknowledged that it was safer to cross at such locations. Route selection by this group was based on assumptions of traffic level and the directness of the route in relation to the destination. Routes, where traffic levels were lower, were often selected because these were found to be less stressful. This supports sub-hypothesis 4(iv) that route attractiveness plays a significant role in route choice. However, where time constraints on the journey existed, directness of route became a more important consideration.

It was evident, from listening to children, that they are subject to parental constraints, resulting from parental perceptions of the traffic danger encountered on routes to and from school generally. This concern with child pedestrian safety was reflected in lower levels of independence. Children were often accompanied by friends or parents. The children themselves were found to share their parent's concern of crossing main roads. Typically, these journeys, as with the elderly, were based around the use of pedestrian crossing facilities.

7.4.3 Summary

Results from the study have established that behavioural modification occurs in response to changing traffic conditions in a manner consistent with the concept of the traffic barrier. As expected, data has indicated that the extent to which the traffic barrier is experienced by pedestrians on main central area urban streets is determined by traffic flow. Speed conditions at the time of crossing were found to have a lesser effect. Analysis also indicated that perceived heavy traffic flows led to the selection of formal crossing locations and were associated with low levels of safety, high levels of crossing difficulty and low levels of pedestrian crossing amenity. Unexpectedly, however, results from the in-depth interviews indicated that before the pedestrian journey is embarked upon that the traffic barrier can influence decisions about route choice and crossing strategies.

7.5 IMPLICATIONS FOR FURTHER RESEARCH

This study has confirmed that the traffic barrier effect should be an important consideration in the decision-making process. It has wide implications for the movement requirements of pedestrians; requirements which are often overlooked.

Limitations regarding policy and practice have been referred to. In particular the Department of Transport's definition of severance has been criticised on the grounds of ignoring pedestrian needs. Further work on traffic barriers in different street contexts is needed to develop criteria regarding barrier effect levels which can be related to pedestrian needs. Practice would clearly benefit from informed policy decisions based on further behavioural research.

Measures of the traffic barrier, based only on observation, are, at best, partial. For example, measures associated with observations of pedestrian behaviour such as pedestrian delay and acceptance gaps are only concerned with those pedestrians who actually attempt to cross the road. Pedestrians who are deterred from crossing the road and who reschedule activity or use different routes due to the effect of the traffic barrier, are clearly left out of assessments of the traffic barrier. Work undertaken in this study indicates that the study of traffic barriers requires a wider framework and that this framework should rely on a range of research techniques. This suggests that the assessment of pedestrian environments should move away from a reliance on only traditional quantitative methods towards a planning framework which also encompasses qualitative methods. This would contribute to the development of improved insights into the operation and function of traffic barriers in particular contexts.

Barrier effects have been identified as not being uniform within a street section, and the extent to which the barrier is experienced has been shown to vary with age, trip purpose, and the land use pattern within the street section under study. Retail activity, bus stops and cashpoint machines are major attractors encouraging crossing activity. Pedestrians undertaking less essential trips for example, trips associated with meeting friends and leisure activities, and trips where an element of choice is involved, are more likely to re-arrange trips, take alternative routes or even change to another mode of transport as a result of adverse traffic conditions.

Delay has been shown to be a variable which can be used in association with measures of traffic flow and speed to assess the level of the traffic barrier experienced by those pedestrians who actually decide to cross. It is apparent from the research in this thesis that pedestrian delay could be more widely defined to include delays relating to detours and the rescheduling of pedestrian crossing activity. However, in practice there are clearly time and cost constraints relating to the assessment of delay at locations other than at the kerb. Other measures are clearly required for those pedestrians who do not cross but who are nonetheless affected by the traffic barrier. This would serve to provide a more accurate picture of the actual extent of the traffic barrier effect on pedestrian behaviour.

This study has demonstrated that acceptance gaps can provide an enhanced view of pedestrian/vehicle interaction. The dismissal of acceptance gaps as not particularly fruitful should therefore be re-evaluated. Dismissal of their importance based on poor links between acceptance gaps and accident data are not valid, as acceptance gaps represent a key aspect of a normal crossing strategy whereas accidents are associated with a multitude of factors including driver and pedestrian errors, which do not occur on a frequent basis. Acceptance gaps are closely associated with the traffic speed and flow relationship in each carriageway at the time of crossing and the distribution of acceptance gaps may prove to be a useful indicator of the barrier effect in different situations. It may, for instance, be possible to define minimum standards for an acceptable gap distribution, below which the provision of improved crossing facilities or the implementation of traffic calming schemes is sought. Standards for minimum acceptable gaps would need to be devised for streets of different type, to reflect different land use characteristics, and pedestrian activity levels and patterns. Where the proportions of children and the elderly are high, these standards could be raised. Further research is clearly needed to quantify and explore these possible applications. As with delay however, it should be noted that acceptance gaps, the time gap between vehicles in which the pedestrian decides to cross, also refer to those pedestrians who are actually crossing. It is therefore also a partial measure. This highlights the need for approaches and techniques which can be used to supplement behavioural studies of observable behaviour in a particular street environment.

Given the time consuming and costly nature of behavioural studies, it was considered that a simple measure called the crossing ratio is potentially a useful measure of the barrier effect. This is independent of the pedestrian activity level and should be considered in conjunction with other measures, such as delay, otherwise it could also be criticised for being a partial measure. This study however, found the measure to be useful in measuring different levels of crossing activity by different age groups and from different sides of the street and clearly, could be developed further with associated measures of land use type. The crossing ratio also identified shifts from informal to formal crossing locations;

movement strongly associated with the young and the elderly. Linkages between traffic flow, parking density and the crossing ratio need to be explored further. Further research is needed to assess whether crossing ratios, which are aggregate measures, can be more clearly related to variations in traffic conditions which reflect the traffic barrier. Crossing ratios recorded by time of day in association with traffic flow and parking levels would also allow an element of control to be introduced in relation to crossings made from behind parked vehicles.

Further analysis is required to evaluate variability in ratios with different street and trip activity patterns. Analysis incorporating the crossing ratio could be a useful and simple addition in investigating the impact of traffic flow on pedestrian delay, providing norms can be established for expected ratios in specified circumstances. However, too much variation in the ratios would not allow useful comparisons between street sections to be made. Variation in pedestrian activity has been identified as a particular problem in relation to pedestrian trip pattern modelling efforts.

This study has addressed the role of parked vehicles, an important factor which has received little attention in previous studies. Indications are that pedestrians, crossing from behind parked vehicles, experience reductions in the traffic barrier effect. A high proportion of crossings undertaken from behind parked vehicles are associated with heavy traffic flows, low speeds and shorter acceptance gaps in the nearside carriageway. However, it is not clear whether the high proportion crossing from behind parked vehicles simply reflects the higher level of parking at higher flow level times. Questionnaire survey respondents clearly felt that crossing from behind parked vehicles made it easier to cross into gaps in the oncoming traffic stream, but felt that it did not increase security or safety. Further research is required which examines behaviour and perceptions in response to differing levels of traffic flow and parking activity more closely. Studies on other street types, or street sections with different parking and traffic levels, would assist in clarifying relationships. On sections of street where parking and waiting restrictions are being intensified, often in association with the introduction of bus priority measures, there are important policy implications from impacts on barrier effects and pedestrian behaviour. Further research into parking policy and traffic barriers would be of great interest in this regard, including before and after studies in association with "Red Route" type schemes.

Research has indicated that perceptions of street environments and traffic levels are an important consideration in the study of traffic barriers. Surveys of perceptions and attitudes could play an important part in the policy and decision-making process. Findings have indicated that respondents are sensitive to issues relating to street amenity, traffic levels and street design, and such surveys undertaken on a regular basis before and after the implementation of schemes, could potentially result in improvements in the design of traffic management and traffic calming schemes. The use of survey and in-depth interview techniques which incorporate the use of specially edited video tape of traffic conditions to elicit responses and perceptual data about street environments, could be incorporated into existing practice in before and after appraisals of schemes. Modern portable computing equipment would allow this to be adopted with some flexibility in the field. The image used to elicit responses could also utilise photographic stills although this clearly may result in a lower quality of response in relation to the assessment of traffic conditions.

The quality of the in-depth interview responses obtained in this study would clearly justify the adoption of this technique into future studies of the traffic barrier and the impact of traffic management and traffic calming schemes on pedestrian behaviour. This would also help to avoid over-reliance on partial measures of observed behaviour and help to address a wider set of issues and factors which contribute toward the traffic barrier effect.

7.6 IMPLICATIONS FOR POLICY AND PRACTICE

Current debates surrounding issues relating to travel reduction and the promotion of sustainable transport policies have highlighted the need for policy makers and practitioners to increase their awareness of the contribution that walking and other "green" modes of transport can make to existing transport systems, systems which are currently focused around car-based travel. Assessments of pedestrian travel behaviour and factors affecting pedestrian use of street environments are clearly of great importance in this context. Future monitoring of transport strategies and policy clearly needs to pay greater attention to factors affecting pedestrian needs and movement requirements. This thesis has identified the problems associated with existing methods used in the assessment of pedestrian movement and behaviour.

Central to the thesis is the need for policy to explicitly consider the impacts of traffic on pedestrian behaviour. The concept of the traffic barrier was defined (p9-14 and p378) recognising the impact of traffic within a specified environmental/street context on observable and unobservable behaviour. The concept clearly has the potential for application to other categories of streets, in addition to the tenemental radial routes used in this study, where there is a need to consider explicitly the relationship between pedestrian behaviour and the impact of traffic in policy terms. This approach would promote a greater awareness of the nature of the relationships involved and would highlight the impacts of traffic on both kerbside behaviour and unobserved behaviour. It has been argued that current policy emphasises a partial approach based only on observed behaviour. There is, therefore, a clear need for policy makers to encourage the wider application of techniques based not only on measures of observed behaviour but also on surveys of perceptions and attitudes for added insights into unobserved pedestrian behavioural responses.

There is clearly a dichotomy between techniques used by the research community and those used in practice. Pedestrian behavioural research has sought to use a variety of techniques, for example time lapse photography in the assessment of acceptance gaps. In practice, however, these techniques remain largely unused. Existing methods are based principally around the measurement of traffic flow and speed characteristics of streets before and after the implementation of speed reduction or traffic management measures, the use of PV^2 to justify the installation of crossing facilities and the measurement of pedestrian delay to assess the level of severance associated with a new road scheme. Pedestrian movement studies, undertaken prior to the pedestrianisation of a street or street network, often involve only the measurement of pedestrian flow within existing street networks with little regard to traffic conditions and factors which can affect pedestrian behaviour. This thesis has demonstrated that there are advantages in undertaking traffic surveys combined with the analysis of pedestrian movement and behaviour, supplemented where possible with surveys of pedestrian perceptions and attitudes.

This study has demonstrated that video data collection methods are a valuable tool in the study of pedestrian behaviour, especially where micro-level measures of traffic speed and flow at the time of crossing can be combined with other behavioural measures such as pedestrian delay and acceptance gaps. This method is particularly valuable to practitioners who may require quantitative evidence of behavioural modification in response to different traffic conditions. In monitoring pedestrian behaviour, it is essential that the policy goals are clearly established. This will ultimately affect the choice of behavioural measures. In situations where congested traffic conditions are consistently experienced, there may be little value in assessing pedestrian gap acceptance. The focus might therefore be the effect of traffic on pedestrian delay in these situations. Pedestrian delay and acceptance gaps, when combined with micro-level measures of traffic speed and flow, are clearly of greater importance where the interaction of pedestrians in different traffic conditions is of interest. The crossing ratio could be used if it was considered desirable to assess patterns of pedestrian movement in the street, although further research is required to evaluate the variability of crossing ratio measures. However, if policy goals are changed and additional behavioural measures sought, in light of preliminary findings, the video provides a permanent record of the data which can be re-examined at a later stage.

Reliance on video evidence of observed pedestrian behaviour can, however, provide a partial explanation of the extent to which pedestrian behaviour is modified in response to the impact of traffic. By using questionnaire surveys and/or in-depth interviews, qualitative data can be obtained which can give insights into the features of unobserved pedestrian behaviour. Questionnaire surveys and/or in-depth interview techniques, which incorporate the use of specially edited video tape of traffic conditions to elicit responses and perceptual data about street environments, could be developed and incorporated into before and after assessments of traffic management schemes. Evidence from this thesis indicates that the quality of responses would justify the application of this technique in practice. The increased availability of video technology and the use of modern portable computing equipment could allow this technique to be adopted with some flexibility in the field.

In practice, the use of set-format questionnaire surveys and/or in-depth interviews will only suit specific circumstances. Set-format questionnaire surveys, administered to residents or pedestrians on-street, clearly have advantages associated with the shorter time spent collecting data and planning survey work. In-depth interviews, which may incorporate the use of video, take longer to administer and rely on the assumption of detailed prior knowledge of a particular street environment. The use of the in-depth interview technique, in this study based on the identification of specific age groups, may be harder to achieve in practice where interviews have to be conducted with the agreement of other organisations, such as schools. As a result, these institutions become responsible for providing facilities where the interviews can take place. Undertaking this type of interview, in practice, therefore requires planning and organisation. Where time and cost constraints exist this method may be inappropriate. Data quality may, however, offset time and cost constraints and necessitate the use of in-depth interviews with households resident on the street under study and who possess the required level of knowledge.

Decisions clearly need to be made at the outset as to whether partial representation of the impact of traffic on pedestrian behaviour, resulting from the focus on kerbside behaviour, is acceptable in practice. These decisions relate to the nature of the problem under investigation and the type of street, and choices concerning data collection methods and techniques of assessment. On tenemental radial routes, such as those used in this study, where the problem under investigation may be associated with the impact of traffic flow on pedestrian behaviour, and where high volumes of pedestrian activity are guaranteed for data collection purposes, the use of video possesses clear advantages. It may also be considered appropriate to supplement measures of observed pedestrian behaviour and traffic levels with interview data from either a set format questionnaire or in-depth interview surveys, in order to gain insights into unobserved behaviour, thereby achieving a fuller representation of the extent of the traffic barrier. In situations where pedestrian activity levels are lower than on central area streets it may not be appropriate or cost effective to employ studies of observed pedestrian behaviour using manual or video data collection techniques. On residential streets, for example, where the problems may be associated with excessive traffic speeds and rat running, it may be appropriate to supplement measures of traffic speed with household surveys of residents' perceptions of safety using either the set format or in-depth approach.

The development of policy frameworks within the fields of town planning and traffic engineering need to recognise that different street and land use characteristics can produce different sets of perceptions and behaviour. In addition, methods of data collection in different contexts need to be addressed. This thesis has demonstrated that the study of traffic barriers and insights into the trade-off between pedestrian mobility and safety are important considerations in scheme or policy implementation. The trade-off between pedestrian safety and mobility, a trade-off central to the traffic barrier, has to date been largely ignored. This study has indicated that important pedestrian behaviour modifications arise in response to changes in the traffic barrier but are ignored in traffic engineering practice. The normal practice of casualty data analysis associated with scheme design and implementation has not allowed for, or monitored changes to, pedestrian flow and movement patterns following the introduction of pedestrian crossing facilities. The need to monitor the effect on pedestrian mobility should be a central concern of policy. Such monitoring would provide vital information regarding the implementation of traffic calming and management schemes. This trade-off between pedestrian mobility and safety is fundamental in many traffic management schemes. It should be explicitly considered in the design of such schemes if pedestrian needs are to be adequately provided for.

APPENDIX 1
FIELD WORK AND QUESTIONNAIRE SURVEY FORMS

Form A - Bruntsfield Place Residents' Questionnaire Survey

Edinburgh College of Art

1990-91 : 25 Years of Undergraduate Planning Education in Edinburgh

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RESIDENTS QUESTIONNAIRE

INTRODUCTION

DEAR SIR/MADAM

THIS QUESTIONNAIRE HAS BEEN SENT TO EVERYONE IN YOUR SECTION OF THE STREET. THE SURVEY IS BEING UNDERTAKEN AS PART OF A RESEARCH PROJECT BASED AT HERIOT-WATT UNIVERSITY, HERE IN EDINBURGH. THE RESEARCH HOPES TO FIND OUT WHAT YOU THINK ABOUT TRAFFIC CONDITIONS IN BRUNTSFIELD PLACE, AS A PEDESTRIAN, AND WHAT YOU FEEL SHOULD BE DONE IN BRUNTSFIELD PLACE TO IMPROVE THE CONDITIONS FOR PEDESTRIANS. PLEASE FILL IN THE QUESTIONNAIRE PROVIDED, AND ENCOURAGE ALL FAMILY MEMBERS INCLUDING CHILDREN AND/OR PEOPLE WHO SHARE THE FLAT/HOUSE WITH YOU TO FILL OUT A QUESTIONNAIRE EACH. THE RESULTS FROM THIS SURVEY WILL BE USED TO PROVIDE A BASIS FOR IMPROVING PROVISION FOR PEDESTRIANS IN SUCH STREETS AS BRUNTSFIELD PLACE.

IN TWO WEEKS TIME A MEMBER OF OUR PROJECT TEAM WILL COME AND PICK UP THE FORM.

PLEASE NOTE THAT <u>ANY INFORMATION PROVIDED ON THIS FORM WILL BE TREATED WITH THE UTMOST CONFIDENTIALITY AND CANNOT BE TRACED BACK TO YOU PERSONALLY</u>.

THANK YOU IN ANTICIPATION OF YOUR HELP AND CO-OPERATION.

RESIDENTS QUESTIONNAIRE

SECTION A PERSONAL DETAILS

PLEASE TICK THE APPROPRIATE BOXES

QU1 HOW OLD ARE YOU ? INDICATE YOUR AGE BY TICKING THE APPROPRIATE BOX

- UNDER 11 ☐
- 11 - 18 ☐
- 18 - 24 ☐
- 25 - 65 ☐
- OVER 65 ☐

QU2 ARE YOU MALE OR FEMALE ? (TICK BOX)

- MALE ☐
- FEMALE ☐

QU3 HOW MANY WALKING TRIPS DO YOU USUALLY MAKE ALONG THE STREET YOU LIVE IN ? FOR EXAMPLE ONE TRIP INCLUDES BOTH THE OUTWARD AND RETURN WALKING JOURNEYS.
TICK ONE BOX

- LESS THAN 1 TRIP A WEEK ☐
- 1 TO 2 TRIPS A WEEK ☐
- 3 TO 5 TRIPS A WEEK ☐
- 1 TRIP A DAY ☐
- 2 TRIPS A DAY ☐
- MORE THAN 2 TRIPS A DAY ☐

QU4 WHEN YOU ARE WALKING IN YOUR STREET WHAT IS YOUR WALKING SITUATION MOST FREQUENTLY ?

- WITH CHILD IN PUSH CHAIR ☐
- WITH YOUNG CHILD WALKING ☐
- WITH MORE THAN ONE CHILD ☐
- WITH SHOPPING ☐

IF NONE OF THESE PLEASE GO ON TO THE NEXT QUESTION

QU5(A) DO YOU HAVE DIFFICULTY WALKING ? TICK ONE BOX

- YES ☐
- NO ☐

IF YES PLEASE GO ON TO PART B AND C

(B) PLEASE TICK ONE BOX

- DO YOU USE A WALKING STICK ? ☐
- DO YOU USE A WHEEL CHAIR ? ☐
- DO YOU HAVE A HEALTH PROBLEM WHICH AFFECTS YOUR WALKING ? ☐

(C) IF YOU HAVE ANSWERED PART B, ARE YOU USUALLY.. (TICK ONE BOX)

- ACCOMPANIED ☐
- USUALLY ALONE ☐
- NEVER ACCOMPANIED ☐

SECTION B WALKING

QU6 WHY DO YOU USUALLY GO OUT AS A PEDESTRIAN IN THE STREET YOU LIVE IN ? (ONE REASON ONLY, TICK ONE BOX)

- SHOPPING ☐
- SHOPPING/TO/FROM WORK ☐
- TO/FROM WORK ☐
- PART OF WORK ☐
- TO THE CAR/OTHER FORM OF TRANSPORT ☐
- PERSONAL BUSINESS ☐
- TO/FROM SCHOOL/COLLEGE ☐
- MEETING FRIENDS ☐
- LEISURE ☐

OTHER REASON (PLEASE SPECIFY)________________________________

QU7 DO YOU USUALLY HAVE A CAR AVAILABLE TO YOU ? PLEASE TICK ONE BOX.

- YES ☐
- NO ☐

QU8 WHEN YOU GO OUT AS A PEDESTRIAN WHAT IS YOUR AVERAGE LENGTH OF TIME OF YOUR WALKING TRIP ? PLEASE TICK ONE BOX.

LESS THAN 10 MINUTES ☐

10 TO 20 MINUTES ☐

20 TO 30 MINUTES ☐

MORE THAN 30 MINUTES ☐

QU9 AT WHAT TIME OF DAY DO YOU MOST OFTEN WALK ALONG THE STREET YOU LIVE IN ? PLEASE TICK MORE THAN ONE BOX IF REQUIRED.

BEFORE 8.29 A.M.	☐	2.00 - 3.29 P.M.	☐
8.30 - 9.29 A.M.	☐	3.30 - 5.00 P.M.	☐
9.30 - 11.29 A.M.	☐	AFTER 5.00 P.M.	☐
11.30 - 1.59 P.M.	☐	VARIES	☐

SECTION C STREET AMENITY

QU10 WHICH OF THESE FEATURES OF THE STREET DO YOU FEEL CAUSE OR DONT CAUSE A PROBLEM FOR PEDESTRIANS ? TICK BOXES AS APPROPRIATE

	VERY BAD PROBLEM	BAD PROBLEM	SLIGHT PROBLEM	NO PROBLEM
PARKED CARS	☐	☐	☐	☐
TRAFFIC CONDITIONS	☐	☐	☐	☐
CROSSING THE ROAD	☐	☐	☐	☐
OBSTRUCTION ON PAVEMENT	☐	☐	☐	☐
TRAFFIC NOISE	☐	☐	☐	☐
LOADING/UNLOADING OF VEHICLES	☐	☐	☐	☐
OTHER SPECIFY________________	☐	☐	☐	☐

QU11 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN EDINBURGH IN GENERAL ? (TICK ONE BOX)

VERY BAD	BAD	NEITHER GOOD OR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

QU12 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN THIS STREET ? (TICK ONE BOX)

VERY BAD	BAD	NEITHER GOOD OR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

SECTION D ASSESSMENT OF TRAFFIC CONDITIONS IN THE STREET

QU13(A) ARE THERE ACTIVITIES WHICH TRAFFIC CONDITIONS IN YOUR STREET DISCOURAGE YOU FROM DOING ? (TICK YES OR NO)

YES ☐

NO ☐ IF NO GOTO QU14, IF YES CARRY ON TO PARTS B AND C OF THIS QUESTION

(B) WHAT ARE THESE ACTIVITIES ? (TICK BOXES AS APPROPRIATE)

MEETING FRIENDS	☐	WALKING TO/FROM SCHOOL/COLLEGE	☐
WALKING TO/FROM WORK	☐		
SHOPPING	☐	LEISURE	☐
PERSONAL BUSINESS	☐		

(C) DOES THIS HAPPEN MORE AT SOMETIMES THAN OTHERS ? (TICK ONE BOX)

IN THE MORNING	☐	IN THE EVENING	☐
IN THE AFTERNOON	☐	NOT AT ALL	☐

QU14(A) DO YOU USE ANY OF THE FOLLOWING SHOPS IN BRUNTSFIELD PLACE ? PLEASE INDICATE IN THE BOXES PROVIDED BELOW.

	REGULARLY	OCCASIONALLY	SELDOM	NEVER
NEWSAGENTS	☐	☐	☐	☐
GROCERS	☐	☐	☐	☐
BAKERS	☐	☐	☐	☐
FISHMONGERS	☐	☐	☐	☐
BUTCHERS	☐	☐	☐	☐

(B) WHERE YOU HAVE RESPONDED SELDOM OR NEVER IS THIS BECAUSE OF HEAVY TRAFFIC DISCOURAGING YOU FROM CROSSING THE ROAD OR MAKING THE JOURNEY TO THE SHOPS ? PLEASE TICK ONE BOX.

YES ☐ PARTLY ☐ NO ☐

QU15(A) DO YOU EVER TAKE A DIFFERENT ROUTE WHEN WALKING BECAUSE OF THE TRAFFIC CONDITIONS IN THIS STREET ? (TICK ONE BOX)

YES ☐
NO ☐
NO ALTERNATIVE ROUTE AVAILABLE ☐

IF YES GOTO PART B AND C

(B) DOES THIS HAPPEN AT A SPECIFIC TIME OF THE DAY ? (TICK ONE BOX)

IN THE MORNING ☐
IN THE AFTERNOON ☐
IN THE EVENING ☐
NOT AT ALL ☐

QU16(A) DO THE TRAFFIC CONDITIONS ENCOURAGE YOU TO WALK AT ANY PARTICULAR TIMES?

YES ☐
NO ☐

IF YES TICK ANY OF THE FOLLOWING.
(B) DO YOU CHANGE YOUR WALK JOURNEY FROM...

EARLY MORNING TO MID MORNING ☐
MID MORNING TO LUNCH ☐
LUNCH TO MID AFTERNOON ☐
MID AFTERNOON TO EARLY EVENING ☐
EARLY EVENING TO LATE EVENING ☐

QU17(A) HAVE THE TRAFFIC CONDITIONS EVER ENCOURAGED YOU TO USE ANOTHER MODE OF TRANSPORT ? TICK ONE BOX

YES ☐
NO ☐ IF YES WHICH TYPE OF TRANSPORT TICK ONE BOX IN PART B

(B) TYPE OF TRANSPORT

BUS ☐ TAXI ☐
CAR ☐ OTHER (SPECIFY)____________

QU18 AS A PEDESTRIAN PLEASE INDICATE ON EACH OF THESE SCALES WHICH POSITION BEST DESCRIBES THE STREET YOU LIVE IN FOR YOU ? (TICK ONE BOX IN EACH SCALE)

	1	2	3	4	5	
SAFE	☐	☐	☐	☐	☐	UNSAFE
NO STRESS	☐	☐	☐	☐	☐	HIGH STRESS
NO RISK	☐	☐	☐	☐	☐	HIGH RISK

QU19 HOW WOULD YOU GENERALLY DESCRIBE THE TRAFFIC FLOW IN YOUR STREET FOR EACH TIME PERIOD ? (TICK ONE BOX FOR EACH TIME PERIOD)

	LIGHT	MEDIUM	HEAVY
8.00-9.30 AM	☐	☐	☐
9.30-12.00 AM	☐	☐	☐
12.00-2.00 PM	☐	☐	☐
2.00-4.30 PM	☐	☐	☐
4.30-6.30 PM	☐	☐	☐
6.30-8.00 PM	☐	☐	☐
AFTER 8.00 PM	☐	☐	☐

QU20 IN YOUR STREET WHERE DO YOU USUALLY CROSS THE ROAD........

(A) WHEN TRAFFIC CONDITIONS ARE LIGHT WHERE DO YOU CROSS THE ROAD ? (TICK ONE BOX)

PELICAN CROSSING ☐ CENTRAL REFUGE ☐

ANYWHERE ☐ DONT CROSS ☐

SPECIFIC LOCATION YOU THINK SAFE ☐

AND (B) WHEN TRAFFIC CONDITIONS ARE MEDIUM WHERE DO YOU CROSS THE ROAD ? (TICK ONE BOX)

PELICAN CROSSING ☐ CENTRAL REFUGE ☐

ANYWHERE ☐ DONT CROSS ☐

SPECIFIC LOCATION YOU THINK SAFE ☐

AND (C) WHEN TRAFFIC CONDITIONS ARE HEAVY WHERE DO YOU CROSS THE ROAD ? (TICK ONE BOX).

PELICAN CROSSING ☐ CENTRAL REFUGE ☐

ANYWHERE ☐ DONT CROSS ☐

SPECIFIC LOCATION YOU THINK SAFE ☐

AND (D) WHEN TRAFFIC HAS STOPPED WHERE DO YOU CROSS THE ROAD ? (TICK ONE BOX)

PELICAN CROSSING ☐ CENTRAL REFUGE ☐

ANYWHERE ☐ DONT CROSS ☐

SPECIFIC LOCATION YOU THINK SAFE ☐

QU21 AT WHAT SPEED (MPH) DO YOU THINK TRAFFIC TRAVELS AT IN YOUR STREET MOST OF THE TIME ? (TICK ONE BOX)

0-15	16-20	21-25	26-30	31-35	35 +
☐	☐	☐	☐	☐	☐

QU22(A) DOES THE SPEED OF TRAFFIC IN YOUR STREET HAVE AN EFFECT ON YOU AS A PEDESTRIAN ? (TICK ONE BOX)

YES ☐

NO ☐

IF YES GOTO PART B
(B) PLEASE STATE IN THE SPACE PROVIDED BELOW WHAT EFFECTS THESE ARE ?

SECTION E BELIEF AND VALUE ASSESSMENT

QU23 HOW MANY PEDESTRIANS APPROXIMATELY DO YOU THINK ARE KILLED ON BRITISH ROADS EACH YEAR ?

UNDER 500 ☐

501 - 1000 ☐

1001 - 1500 ☐

1501 -2000 ☐

OVER 2000 ☐

QU24 OF THOSE WHO ARE EITHER KILLED OR INJURED ON OUR ROADS A SUBSTANTIAL NUMBER ARE CHILDREN WHAT DO YOU THINK IS TO BLAME FOR THIS ? PLEASE MARK EACH SCALE OF 1 - 5 TO SHOW YOUR STRENGTH OF AGREEMENT /DISAGREEMENT WITH EACH REASON BELOW.

CHILDS BEHAVIOUR	AGREE	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	DISAGREE
LACK OF SUPERVISION BY PARENTS	AGREE	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	DISAGREE
LACK OF CARE AND ATTENTION BY DRIVERS	AGREE	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	DISAGREE
DRIVING TOO FAST	AGREE	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	DISAGREE

QU25 ON A SCALE OF 1-5 DO YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENT : <u>SOCIETY ENCOURAGES THE VIEW THAT ROAD ACCIDENTS ARE AN INEVITABLE OUTCOME OF THE STYLE OF LIFE WE LEAD ?</u> (TICK ONE BOX)

AGREE ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 DISAGREE

SECTION F WHAT OUGHT TO BE DONE

QU26 WHAT DO YOU THINK OUGHT TO BE DONE IN THIS STREET TO IMPROVE CONDITIONS FOR PEDESTRIANS (TICK UPTO 3 BOXES)

NOTHING	☐	GUARD RAILINGS (OUT)	☐
GUARD RAILINGS (IN)	☐	REDUCE TRAFFIC SPEED	☐
EXTRA CROSSINGS	☐	WIDEN PAVEMENTS	☐
REDUCE OBSTRUCTIONS ON THE PAVEMENT	☐	REDUCE TRAFFIC FLOW	☐
		IMPROVE LOADING/UNLOADING FOR SHOPS	☐
SEATS	☐		
STOP PAVEMENT PARKING	☐		
LANDSCAPING	☐	OTHER (SPECIFY)______________	

SECTION G GENERAL

QU27 WHAT DO YOU THINK WOULD BE THE MAIN FACTOR CONTRIBUTING TO PEDESTRIAN ACCIDENTS IN YOUR STREET? PLEASE PUT ANY COMMENTS IN THE SPACE PROVIDED.

THANKYOU FOR YOUR HELP

Form B - Bruntsfield Place On Street Questionnaire Survey

PEDESTRIAN QUESTIONNAIRE - PILOT STUDY
(ON STREET)

LOCATION (STREET)

RECORD NUMBER

DATE

TIME OF INTERVIEW (24 HOUR)

INTERVIEWER (INITIALS)

<u>INTRODUCTION</u>
GOOD MORNING/GOOD AFTERNOON I AM FROM HERIOT WATT UNIVERSITY. WE ARE CARRYING OUT A SURVEY OF PEDESTRIAN VIEWS ABOUT THE TRAFFIC CONDITIONS IN BRUNTSFIELD PLACE. COULD YOU TELL ME......

<u>SECTION A THE WALK JOURNEY</u>

QU1 WHAT IS YOUR MAIN REASON FOR BEING HERE NOW ? (TICK ONE BOX)

SHOPPING	☐	PERSONAL BUSINESS	☐
SHOPPING/TO/ FROM WORK	☐	TO/FROM SCHOOL/ COLLEGE	☐
TO/FROM WORK	☐	MEETING FRIENDS	☐
PART OF WORK	☐	LEISURE	☐
TO THE CAR/OTHER FORM OF TRANSPORT	☐		

OTHER (SPECIFY)

QU2 WHEREABOUTS DO YOU LIVE ? EDINBURGH ☐
OTHER ☐

QU3 HOW DID YOU TRAVEL TO THIS STREET TODAY ?

CAR DRIVER	☐	TAXI	☐
CAR PASSENGER	☐	CYCLE	☐
BUS	☐	MOTOR CYCLE	☐
COACH	☐	WALK	☐

IF WALKING STATED GO TO QU4 IF NOT GO TO QU5

QU4 WHERE DID YOU START YOUR WALK FROM ? (ENTER STREET NAME IN THE SPACE PROVIDED BELOW)

QU5 HOW MUCH TIME ALTOGETHER DO YOU EXPECT TO BE WALKING BEFORE THIS JOURNEY ENDS ?

______________HOURS ____________MINUTES

QU6(A) HOW OFTEN DO YOU WALK ALONG THIS STREET ? NOTE THAT ONE TRIP INCLUDES BOTH THE OUTWARD AND RETURN WALKING JOURNEYS.

TICK ONE BOX

LESS THAN 1 TRIP A WEEK	☐
1 TO 2 TRIPS A WEEK	☐
3 TO 5 TRIPS A WEEK	☐
1 TRIP A DAY	☐
2 TRIPS A DAY	☐
MORE THAN 2 TRIPS A DAY	☐

(B) AT WHAT TIME OF DAY DO YOU MOST OFTEN WALK ALONG HERE ?

(TICK MORE THAN ONE BOX AS REQUIRED)

BEFORE 8.29 A.M.	☐	2.00 - 3.29 P.M.	☐
8.30 - 9.29 A.M.	☐	3.30 - 5.00 P.M.	☐
9.30 - 11.29 A.M.	☐	AFTER 5.00 P.M.	☐
11.30 - 1.59 P.M.	☐	VARIES	☐

SECTION B STREET AMENITY

QU7 WHICH OF THESE FEATURES OF THIS STREET DO YOU FEEL CAUSE OR DONT CAUSE A PROBLEM FOR PEDESTRIANS ?

DONT PROMPT TICK BOXES AS APPROPRIATE

	VERY BAD PROBLEM	BAD PROBLEM	SLIGHT PROBLEM	NO PROBLEM
PARKED CARS	☐	☐	☐	☐
TRAFFIC CONDITIONS	☐	☐	☐	☐
CROSSING THE ROAD	☐	☐	☐	☐
PAVEMENT OBSTRUCTION	☐	☐	☐	☐
TRAFFIC NOISE	☐	☐	☐	☐
LOADING/UNLOADING OF VEHICLES	☐	☐	☐	☐
OTHER SPECIFY ____________	☐	☐	☐	☐

QU8 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN EDINBURGH IN GENERAL ? (TICK ONE BOX)

VERY BAD	BAD	NEITHER GOOD OR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

QU9 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN THIS STREET ? (TICK ONE BOX)

VERY BAD	BAD	NEITHER GOOD OR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

SECTION C ASSESSMENT OF TRAFFIC CONDITIONS IN THE STREET

QU10(A) ARE THERE ACTIVITIES WHICH TRAFFIC CONDITIONS DISCOURAGE YOU FROM DOING ? (TICK YES OR NO)

YES ☐

NO ☐

IF NO GO TO QU11, IF YES CARRY ON TO PARTS B AND C

(B) WHAT ARE THESE ACTIVITIES ? (TICK BOXES AS APPROPRIATE)

MEETING FRIENDS	☐	WALKING TO/FROM SCHOOL/COLLEGE	☐
WALKING TO/FROM WORK	☐	LEISURE	☐
SHOPPING	☐	PERSONAL BUSINESS	☐

(C) DOES THIS HAPPEN MORE AT SOME TIMES THAN OTHERS ? (TICK ONE BOX)

IN THE MORNING	☐	IN THE EVENING	☐
IN THE AFTERNOON	☐	NOT AT ALL	☐

QU11(A) DO THE TRAFFIC CONDITIONS IN THIS STREET ENCOURAGE YOU TO TAKE ANOTHER ROUTE WHEN WALKING ? (TICK ONE BOX)

YES ☐ NO ALTERNATIVE ROUTE AVAILABLE ☐

NO ☐

IF YES GO TO PARTS B AND C

(B) DOES THIS HAPPEN AT A SPECIFIC TIME OF DAY (TICK ONE BOX)

IN THE MORNING ☐

IN THE AFTERNOON ☐

IN THE EVENING ☐

NOT AT ALL ☐

(C) DO THE TRAFFIC CONDITIONS ENCOURAGE YOU TO WALK AT A ANOTHER TIME ?

YES ☐

NO ☐

IF YES, DO YOU CHANGE THE TIME OF YOUR WALK JOURNEY FROM ...... (TICK ONE BOX)

EARLY MORNING TO MID MORNING ☐

MID MORNING TO LUNCH ☐

LUNCH TO AFTERNOON ☐

MID AFTERNOON TO EARLY EVENING ☐

EARLY EVENING TO LATE EVENING ☐

QU12(A) AS A PEDESTRIAN HAVE THE TRAFFIC CONDITIONS ENCOURAGED YOU TO USE ANOTHER MODE OF TRANSPORT RATHER THAN WALK ? (TICK ONE BOX)

YES ☐

NO ☐ IF YES WHICH FORM OF TRANSPORT TICK ONE BOX IN

(B)

BUS ☐ TAXI ☐

CAR ☐ OTHER SPECIFY ☐

QU13 AS A PEDESTRIAN PLEASE INDICATE ON EACH OF THESE SCALES WHICH POSITION BEST DESCRIBES THIS STREET FOR YOU ? (TICK ONE BOX IN EACH SCALE)

	1	2	3	4	5	
SAFE	☐	☐	☐	☐	☐	UNSAFE
NO STRESS	☐	☐	☐	☐	☐	HIGH STRESS
NO RISK	☐	☐	☐	☐	☐	HIGH RISK

QU14 HOW WOULD YOU CURRENTLY DESCRIBE THE TRAFFIC FLOW IN THIS STREET AT THIS TIME? (TICK ONE BOX)

LIGHT	MEDIUM	HEAVY
☐	☐	☐

QU15 AT WHAT SPEED (MPH) DO YOU THINK MOST TRAFFIC IS CURRENTLY TRAVELLING AT ? (TICK ONE BOX)

0-15	16-20	21-25	26-30	31-35	35 +
☐	☐	☐	☐	☐	☐

QU16(A) DOES THE SPEED OF TRAFFIC IN THIS STREET HAVE AN EFFECT ON YOU AS A PEDESTRIAN ? (TICK ONE BOX)

YES ☐

NO ☐

IF YES GO TO PART B
(B) WHAT EFFECTS ARE THESE ? (NOTE ANY COMMENTS)

THANK RESPONDENT FOR HELP

FILL OUT THE CLASSIFICATION DATA THIS IS IMPORTANT

SECTION D CLASSIFICATION DATA (FILL OUT ON COMPLETION OF INTERVIEW) TICK BOXES AS APPROPRIATE

AGE
- UNDER 18 ☐
- 18 - 65 ☐
- OVER 65 ☐

SEX
- MALE ☐
- FEMALE ☐

WALKING SITUATION

	YES	NO
WITH CHILD IN PUSHCHAIR	☐	☐
WITH CHILD WALKING	☐	☐
WITH MORE THAN ONE CHILD	☐	☐
WITH SHOPPING	☐	☐
WITH LUGGAGE	☐	☐
WITH BICYCLE	☐	☐
WITH ONE ADULT	☐	☐
WITH SEVERAL ADULTS	☐	☐
ALONE	☐	☐
WITH SEVERAL CHILDREN	☐	☐

WALKING ABILITY
- FULLY ABLE ☐
- WALKING STICK ☐
- WHEEL CHAIR ☐
- WALKING DIFFICULTY ☐
- STATED HEALTH PROBLEM ☐

WEATHER RAINING ☐ DRY ☐ BRIGHT ☐ DULL ☐

Form C - Raeburn Place Residents' Questionnaire Survey

Edinburgh College of Art

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DEAR SIR/MADAM

RESIDENTS QUESTIONNAIRE

THIS QUESTIONNAIRE HAS BEEN SENT TO EVERYONE IN YOUR SECTION OF THE STREET. THE SURVEY IS BEING UNDERTAKEN AS PART OF A RESEARCH PROJECT BASED AT HERIOT WATT UNIVERSITY, HERE IN EDINBURGH. THE RESEARCH HOPES TO FIND OUT WHAT YOU THINK ABOUT TRAFFIC CONDITIONS IN RAEBURN PLACE, AS A PEDESTRIAN, AND WHAT YOU FEEL SHOULD BE DONE IN RAEBURN PLACE TO IMPROVE THE CONDITIONS FOR PEDESTRIANS. PLEASE FILL IN THE QUESTIONNAIRE PROVIDED, AND ENCOURAGE ALL FAMILY MEMBERS INCLUDING CHILDREN AND/OR PEOPLE WHO SHARE THE FLAT/HOUSE WITH YOU TO FILL OUT A QUESTIONNAIRE EACH. THE RESULTS FROM THIS SURVEY WILL BE USED TO PROVIDE A BASIS FOR IMPROVING PROVISION FOR PEDESTRIANS IN SUCH STREETS AS RAEBURN PLACE.

IN ONE WEEKS TIME A MEMBER OF OUR PROJECT TEAM WILL COME AND PICK UP THE FORM.

PLEASE NOTE THAT <u>ANY INFORMATION PROVIDED ON THIS FORM WILL BE TREATED WITH THE UTMOST CONFIDENTIALITY AND CANNOT BE TRACED BACK TO YOU PERSONALLY</u>.

IF YOU HAVE ANY QUERIES REGARDING THIS QUESTIONNAIRE PLEASE CONTACT ME AT THE ABOVE ADDRESS.

THANK YOU IN ANTICIPATION OF YOUR HELP AND COOPERATION.

YOURS FAITHFULLY

Julian Hine

JULIAN HINE

SECTION A: WALKING

Q.1 HOW MANY WALKING TRIPS DO YOU USUALLY MAKE ALONG RAEBURN PLACE ? FOR EXAMPLE ONE TRIP INCLUDES BOTH THE OUTWARD AND RETURN WALKING JOURNEYS. (TICK ONE BOX)

LESS THAN 1 TRIP A WEEK ☐

1 TO 2 TRIPS A WEEK ☐

3 TO 5 TRIPS A WEEK ☐

1 TRIP A DAY ☐

2 TRIPS A DAY ☐

MORE THAN 2 TRIPS A DAY ☐

Q.2 WHEN YOU ARE WALKING IN RAEBURN PLACE WHAT IS YOUR WALKING SITUATION MOST FREQUENTLY?

WITH CHILD IN PUSH CHAIR ☐

WITH YOUNG CHILD WALKING ☐

WITH MORE THAN ONE CHILD ☐

WITH SHOPPING ☐

IF NONE OF THESE PLEASE GO ON TO THE NEXT QUESTION

Q.3(A) DO YOU HAVE DIFFICULTY WALKING? (TICK ONE BOX)

YES ☐

NO ☐ IF YES PLEASE GO ON TO PART B AND C

(B) (PLEASE TICK ONE BOX)

DO YOU USE A WALKING STICK ? ☐

DO YOU USE A WHEEL CHAIR ? ☐

DO YOU HAVE A HEALTH PROBLEM WHICH AFFECTS YOUR WALKING? ☐

(C) IF YOU HAVE ANSWERED PART B, ARE YOU .. (TICK ONE BOX)

USUALLY ACCOMPANIED ☐

USUALLY ALONE ☐

NEVER ACCOMPANIED/ ALWAYS ALONE ☐

Q.4 WHY DO YOU MOST OFTEN GO OUT AS A PEDESTRIAN IN RAEBURN PLACE? (GIVE ONE REASON ONLY, TICK ONLY ONE BOX)

SHOPPING	☐	PERSONAL BUSINESS	☐
SHOPPING/TO/FROM WORK	☐	TO/FROM SCHOOL/COLLEGE	☐
TO/FROM WORK	☐	MEETING FRIENDS	☐
PART OF WORK	☐	LEISURE	☐
TO THE CAR/OTHER FORM OF TRANSPORT	☐		

OTHER REASON (PLEASE SPECIFY) ______________________

____

____

Q.5 DO YOU USUALLY HAVE A CAR AVAILABLE TO YOU? (PLEASE TICK ONE BOX)

YES ☐

NO ☐

Q.6 WHEN YOU GO OUT AS A PEDESTRIAN WHAT IS THE AVERAGE LENGTH OF TIME OF YOUR WALKING TRIP? (PLEASE TICK ONLY ONE BOX)

LESS THAN 10 MINUTES ☐

10 TO 20 MINUTES ☐

20 TO 30 MINUTES ☐

MORE THAN 30 MINUTES ☐

Q.7 WHEN YOU GO OUT AS A PEDESTRIAN WHAT IS THE AVERAGE DISTANCE OF YOUR WALKING TRIP? (PLEASE TICK ONLY ONE BOX)

UNDER 50 YARDS ☐

OVER 50 YARDS - 1 MILE ☐

1 MILE OR MORE ☐

Q.8 AT WHAT TIME OF DAY DO YOU USUALLY WALK ALONG RAEBURN PLACE? (PLEASE TICK MORE THAN ONE BOX IF REQUIRED)

BEFORE 8.30 A.M.	☐	2.00 - 3.29 P.M.	☐
8.30 - 9.29 A.M.	☐	3.30 - 5.00 P.M.	☐
9.30 - 11.29 A.M.	☐	AFTER 5.00 P.M.	☐
11.30 - 1.59 P.M.	☐	VARIES	☐

SECTION B: CONDITIONS FOR PEDESTRIANS IN RAEBURN PLACE

Q.9 AS A PEDESTRIAN HOW DO YOU FEEL ABOUT THESE FEATURES FOUND ON RAEBURN PLACE ? PLEASE TICK ONE BOX FOR EACH OF THESE FEATURES.

	VERY BAD	BAD	NEITHER GOOD NOR BAD	GOOD	VERY GOOD
PARKED CARS	☐	☐	☐	☐	☐
TRAFFIC LEVEL	☐	☐	☐	☐	☐
PAVEMENT OBSTRUCTIONS	☐	☐	☐	☐	☐
TRAFFIC NOISE	☐	☐	☐	☐	☐
LOADING/UNLOADING OF VEHICLES	☐	☐	☐	☐	☐
TRAFFIC FUMES	☐	☐	☐	☐	☐
TRAFFIC SPEED	☐	☐	☐	☐	☐
OTHER: PLEASE SPECIFY	☐	☐	☐	☐	☐

____

Q.10 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN EDINBURGH IN GENERAL? (TICK ONLY ONE BOX)

VERY BAD	BAD	NEITHER GOOD NOR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

Q.11 HOW DO YOU FEEL ABOUT CONDITIONS FOR PEDESTRIANS IN RAEBURN PLACE? (TICK ONLY ONE BOX)

VERY BAD	BAD	NEITHER GOOD NOR BAD	GOOD	VERY GOOD
☐	☐	☐	☐	☐

Q.12 HOW WOULD YOU GENERALLY DESCRIBE THE TRAFFIC FLOW IN RAEBURN PLACE FOR EACH TIME PERIOD? (TICK ONE BOX FOR EACH TIME PERIOD)

	LIGHT	MEDIUM	HEAVY
8.00-9.30 AM	☐	☐	☐
9.30-12.00 AM	☐	☐	☐
12.00-2.00 PM	☐	☐	☐
2.00-4.30 PM	☐	☐	☐
4.30-6.30 PM	☐	☐	☐
6.30-8.00 PM	☐	☐	☐
AFTER 8.00 PM	☐	☐	☐

Q.13 AT WHAT SPEED (MPH) DO YOU THINK TRAFFIC TRAVELS AT IN RAEBURN PLACE MOST OF THE TIME? (TICK ONE BOX)

0-15	16-20	21-25	26-30	31-35	35 +
☐	☐	☐	☐	☐	☐

Q.14(A) DOES THE SPEED OF TRAFFIC IN RAEBURN PLACE HAVE AN EFFECT ON YOU AS A PEDESTRIAN? (TICK ONE BOX)

YES ☐

NO ☐

IF YES GO TO PART B

(B) PLEASE STATE BELOW WHAT EFFECTS THESE ARE?

Q.15(A) ARE THERE ACTIVITIES ASSOCIATED WITH WALKING WHICH TRAFFIC CONDITIONS IN RAEBURN PLACE DISCOURAGE YOU FROM DOING? (TICK YES OR NO)

YES ☐

NO ☐

IF NO GO TO Q.13, IF YES CARRY ON TO PARTS B AND C OF THIS QUESTION

(B) WHAT ARE THESE ACTIVITIES? (TICK BOXES AS APPROPRIATE)

MEETING FRIENDS	☐	WALKING TO/FROM SCHOOL/COLLEGE	☐
WALKING TO/FROM WORK	☐		
SHOPPING	☐	LEISURE	☐
PERSONAL BUSINESS	☐		

(C) DOES THIS HAPPEN MORE AT CERTAIN TIMES OF DAY? (TICK ONLY ONE BOX)

NO ☐

YES ☐

IF YES, AT WHAT TIME IS THIS? PLEASE TICK MORE THAN ONE BOX IF REQUIRED.

BEFORE 8.30 A.M.	☐	2.00 - 3.29 P.M.	☐
8.30 - 9.29 A.M.	☐	3.30 - 5.00 P.M.	☐
9.30 - 11.29 A.M.	☐	AFTER 5.00 P.M.	☐
11.30 - 1.59 P.M.	☐	VARIES	☐

(D) DO TRAFFIC CONDITIONS LEAD YOU TO SWITCH THE TIMES OF ANY ACTIVITIES ASSOCIATED WITH WALKING? (PLEASE TICK ONE BOX)

YES ☐

NO ☐

IF YES PLEASE INDICATE THE TIMES OF THESE SHIFTS INVOLVED AND THE ACTIVITY INVOLVED IN THE SPACES PROVIDED.

FROM (TIME)	TO (TIME)	ACTIVITY
________	________	________
________	________	________
________	________	________
________	________	________

Q.16(A) DO YOU EVER TAKE A DIFFERENT ROUTE WHEN WALKING BECAUSE OF THE TRAFFIC CONDITIONS IN RAEBURN PLACE? (TICK ONE BOX)

YES ☐

NO ☐

NO ALTERNATIVE ROUTE AVAILABLE ☐

IF YES GO TO PART B AND C

(B) DOES THIS HAPPEN AT A SPECIFIC TIME OF THE DAY? (TICK ONE BOX)

NO ☐

YES ☐

(C) IF YES, AT WHAT TIMES DO YOU TAKE A DIFFERENT ROUTE WHEN WALKING? PLEASE TICK MORE THAN ONE BOX IF REQUIRED.

BEFORE 8.30 A.M.	☐	2.00 - 3.29 P.M.	☐
8.30 - 9.29 A.M.	☐	3.30 - 5.00 P.M.	☐
9.30 - 11.29 A.M.	☐	AFTER 5.00 P.M.	☐
11.30 - 1.59 P.M.	☐	VARIES	☐

Q.17(A) HAVE THE TRAFFIC CONDITIONS IN RAEBURN PLACE ENCOURAGED YOU TO SWITCH FROM WALKING TO ANOTHER MODE OF TRANSPORT? TICK ONE BOX.

YES ☐

NO ☐

IF YES WHICH TYPE OF TRANSPORT? (TICK ONE BOX IN PART B)

(B) TYPE OF TRANSPORT

BUS	☐	TAXI	☐
CAR	☐	OTHER (SPECIFY)____________	

SECTION C: CROSSING THE ROAD IN RAEBURN PLACE

Q.18 AS A PEDESTRIAN PLEASE INDICATE ON EACH OF THESE SCALES WHICH POSITION BEST DESCRIBES RAEBURN PLACE FOR YOU. (TICK ONE BOX IN EACH SCALE)

	1	2	3	4	5	
SAFE	☐	☐	☐	☐	☐	UNSAFE
EASY TO CROSS	☐	☐	☐	☐	☐	DIFFICULT TO CROSS

Q.19 IN RAEBURN PLACE WHERE DO YOU USUALLY CROSS THE ROAD?

(A) WHEN TRAFFIC FLOWS ARE LIGHT? (TICK ONE BOX)

PELICAN CROSSING	☐	DON'T CROSS	☐
ANYWHERE	☐	OTHER SPECIFIC LOCATION YOU THINK SAFE	☐

AND (B) WHEN TRAFFIC FLOWS ARE MEDIUM? (TICK ONE BOX)

PELICAN CROSSING	☐	DON'T CROSS	☐
ANYWHERE	☐	OTHER SPECIFIC LOCATION YOU THINK SAFE	☐

AND (C) WHEN TRAFFIC FLOWS ARE HEAVY? (TICK ONE BOX)

PELICAN CROSSING	☐	DON'T CROSS	☐
ANYWHERE	☐	OTHER SPECIFIC LOCATION YOU THINK SAFE	☐

AND (D) WHEN TRAFFIC HAS STOPPED? (TICK ONE BOX)

PELICAN CROSSING	☐	DON'T CROSS	☐
ANYWHERE	☐	OTHER SPECIFIC LOCATION YOU THINK SAFE	☐

Q.20(A) DO YOU EVER CROSS RAEBURN PLACE FROM BEHIND PARKED VEHICLES?

YES ☐

NO ☐

IF YES GO TO PART B

(B) WHEN CROSSING RAEBURN PLACE FROM BEHIND A PARKED VEHICLE DOES THIS (TICK APPROPRIATE BOXES)

	YES	NO	DONT KNOW
INCREASE FEELINGS OF SECURITY AND SAFETY?	☐	☐	☐
MAKE IT EASIER TO CROSS IN TO THE GAPS BETWEEN ONCOMING VEHICLES?	☐	☐	☐
MAKE IT HARDER TO SEE ONCOMING TRAFFIC?	☐	☐	☐

Q.21 WHAT PURPOSE DO YOU USUALLY CROSS RAEBURN PLACE FOR? (TICK ONLY ONE BOX) TO GET TO THE

- BUS STOP ☐
- CAR ☐
- SHOPS ☐
- SCHOOL/COLLEGE ☐
- WORK ☐
- OTHER: PLEASE SPECIFY ☐ ____________

Q.22 DO TRAFFIC CONDITIONS DETER YOU FROM CROSSING RAEBURN PLACE? TICK BOXES AS APPROPRIATE

	YES	NO	DONT KNOW
GENERALLY	☐	☐	☐
WHEN TRAFFIC FLOWS ARE LIGHT	☐	☐	☐
WHEN TRAFFIC FLOWS ARE MEDIUM	☐	☐	☐
WHEN TRAFFIC FLOWS ARE HEAVY	☐	☐	☐

Q.23 DO YOU RESCHEDULE PEDESTRIAN TRIPS TO AVOID CROSSING RAEBURN PLACE? TICK BOXES AS APPROPRIATE

	YES	NO	DONT KNOW
GENERALLY	☐	☐	☐
WHEN TRAFFIC FLOWS ARE LIGHT	☐	☐	☐
WHEN TRAFFIC FLOWS ARE MEDIUM	☐	☐	☐
WHEN TRAFFIC FLOWS ARE HEAVY	☐	☐	☐

SECTION C: WHAT OUGHT TO BE DONE

Q.24 WHAT DO YOU THINK OUGHT TO BE DONE IN THIS STREET TO IMPROVE CONDITIONS FOR PEDESTRIANS? (TICK UP TO 3 BOXES)

- NOTHING ☐
- GUARD RAILINGS (IN) ☐
- EXTRA CROSSINGS ☐
- REDUCE OBSTRUCTIONS ON THE PAVEMENT ☐
- GUARD RAILINGS (OUT) ☐
- REDUCE TRAFFIC SPEED ☐
- WIDEN PAVEMENTS ☐
- REDUCE TRAFFIC FLOW ☐
- IMPROVE LOADING/UNLOADING FOR SHOPS ☐
- SEATS ☐
- STOP PAVEMENT PARKING ☐
- LANDSCAPING ☐
- OTHER (SPECIFY) ____________

SECTION D: PERSONAL DETAILS

PLEASE FILL OUT THE FOLLOWING SECTION AS THE AMOUNT PEOPLE GET OUT AND ABOUT AS PEDESTRIANS IS AFFECTED BY AGE, EMPLOYMENT AND SEX.

Q.25 HOW OLD ARE YOU? INDICATE YOUR AGE BY TICKING THE APPROPRIATE BOX

- UNDER 11 ☐
- 11 - 18 ☐
- 18 - 24 ☐
- 25 - 65 ☐
- OVER 65 ☐

Q.26 ARE YOU MALE OR FEMALE? (TICK BOX)

- MALE ☐
- FEMALE ☐

Q.27 WHAT TYPE OF EMPLOYMENT ARE YOU CURRENTLY IN? (TICK ONE BOX)

- FULL EMPLOYMENT ☐
- PART-TIME EMPLOYMENT ☐
- NONE ☐
- STUDENT ☐

THANK YOU FOR YOUR HELP

Form D - Personal In-Depth Interview Schedule

INTERVIEW SCHEDULE

INTRODUCTION

This interview is part of a study which is looking into the impact of traffic on pedestrian behaviour. I would like to ask you some questions about what it is like being a pedestrian in Edinburgh. Later on in the interview I will be showing you some excerpts of video recordings to help in asking you some questions on your experiences as a pedestrian.

The video was taken on Raeburn Place in Edinburgh, this street was taken to represent a category of main, radial streets. The following questions therefore refer to your behaviour and crossing experience on these types of streets generally.

I would like to tape this interview, it is important that I record your own words.
Any information that you give me will be treated in confidence.

PERSONAL

To introduce the survey I would like to ask you some questions on your age and mobility which relate to your pedestrian experiences.

Could you tell me your age ?

Do you experience difficulty walking due to a health (disability) problem ?
* Prompts to obtain more information:
How does this affect your travel choices ?
To what extent are you reliant on help from a friend or neighbour or accompanied on walking trips ?
Do you need assistance when out walking ?
How does this affect your decisions about choosing where/when to cross a road ?

Do you have a car available to you which you can drive ?
* Prompts to obtain more information:
Do you rely on family, friends or neighbours for lifts ?
How does this affect your travel choices ?
How does it affect your choices about walking ?

THRESHOLD ASSESSMENT

Please watch the following video tape carefully. Replay this tape after preview.

People often talk of traffic conditions being light, medium or heavy. Please tell me the point at which traffic ceases to be light and when it starts to become heavy (middle range by definition is medium traffic flow).

TRAVEL AS A PEDESTRIAN

Thinking back to a typical week, perhaps last week, did you go out as a pedestrian ?
Where did you go ?
* Prompts to obtain more information:
Get respondent to restructure on a daily basis where possible and use prompts accordingly.
Distinguish by trip purposes bus stop/shops/doctors/special trips and by essential or optional trips.
Do you have to cross main roads on foot as part of these walking trips ?
Where would you cross the main road(s) ?
Why do you take that route ?
Do you remember what the traffic conditions were like ? How would you describe them ?
At what times of day would you say these journeys are undertaken ?
Are you usually alone or accompanied when you are undertaking these journeys ?

How many journeys are made foot ?
Are special or long trips made in the car ?
How long would you say a typical journey on foot would take you ?
You have described to me your travel patterns and journeys over a typical week in some detail.
How do the traffic and street conditions affect you ?
* Prompts to obtain more information:
How do the conditions affect you on main roads and minor roads ?
Are they different ? Could you describe these ?
(Distinguish between optional and essential trips where possible).
Are there any difficulties or problems you experience in these situations ?
Could you describe these ?
Do you find that your behaviour changes in these different situations ?
How does the way you cross change ?
(Distinguish between optional and essential trips where possible).

Are there circumstances where you feel so unsafe you won't cross the road ?
* Prompts to obtain more information:
Is this the case just on main roads ? What about minor roads ?
Are there certain street features which affect your feelings ? (traffic noise/parked cars/pavement obstructions/traffic fumes/traffic speed/level of traffic)
Could you describe how you feel ? (Check for feelings of security where possible).
Do you rearrange your decision to cross (different location/time) ?
Do you reschedule your journey to avoid these feelings ?
For more important journeys do you ignore your feelings and go out any way ? (Distinguish between essential and optional).

PLEASE WATCH THE FOLLOWING VIDEO TAPE CAREFULLY, THE FOLLOWING QUESTIONS REFER TO EXCERPTS FROM THIS AND YOUR EXPERIENCES AS A PEDESTRIAN IN THESE DIFFERENT SITUATIONS.

AFTER THE PREVIEW SHOW RESPONDENT THE SELECTED VIDEO EXCERPTS.
CROSSING THE ROAD
After watching the video tape would you tell me what you would do in these traffic conditions ?
* Prompts to obtain more information:

Would you decide to cross in these conditions ? If the response is no go to the examples at the end of this section.
How would you cross in these conditions ? What would you do ? Check for running/walking and use of parked cars in the crossing task.
Please indicate on the screen if there is a particular point on the tape where you would
cross ? (time/location).
Would you move to the formal crossing point further along if you decided not to cross ?
Would this change depending on the importance of the journey ?
How do you think your behaviour has changed from the description you gave me for an earlier excerpt ?
Suppose you were planning a journey where you had the choice whether or not to make that journey would you cross in these traffic conditions ?
Would you cross, rearrange the journey to another time or not go ?
Would you wait at the point you had chosen to cross from until there was a gap in the
traffic ?
Would you go to a Pelican Crossing ?
Suppose you were planning a journey which you had to make which involved crossing in these traffic
conditions ?
Would you cross, rearrange the journey to another time or not go ?
Would you wait at the point you had chosen to cross from until there was a gap in the
traffic ?
Would you go to a Pelican Crossing ?
How do you think your behaviour has changed from the description you gave me in an earlier excerpt ?

What feelings as a pedestrian does the street/traffic environment portrayed in the video you have just seen evoke for you ?
* Prompts to obtain more information:
How would you describe your feelings ?
Which aspects of the street environment particularly promote this experience ?
Do you think you feelings change depending on the importance of the journey ?
How have you feelings changed from the description you gave me for an earlier excerpt ?

GENERAL
How would you like to see the situation on these types of roads improved for pedestrians ?

You have been very helpful, are there any final thoughts you would like to share with me concerning your experiences as a pedestrian, or your thoughts regarding this interview.

Traffic Speed Record Form

```
TRAFFIC SPEEDS

TIME PERIOD START
            FINISH

EASTBOUND
```

```
WESTBOUND
```

Pedestrian Count Form

COUNT FORM

START TIME________FINISH TIME ________

MALE

A) UNDER 18	(B) 18-65	(C) OVER 65
TOTAL	TOTAL	TOTAL

A ☐ ☐ ☐
B ☐ ☐ ☐
C ☐ ☐ ☐

FEMALE

A) UNDER 18	(B) 18-65	(C) OVER 65
TOTAL	TOTAL	TOTAL

A ☐ ☐ ☐
B ☐ ☐ ☐
C ☐ ☐ ☐

MALE

A) UNDER 18	(B) 18-65	(C) OVER 65
TOTAL	TOTAL	TOTAL

A ☐ ☐ ☐
B ☐ ☐ ☐
C ☐ ☐ ☐

FEMALE

A) UNDER 18	(B) 18-65	(C) OVER 65
TOTAL	TOTAL	TOTAL

A ☐ ☐ ☐
B ☐ ☐ ☐
C ☐ ☐ ☐

Vehicle Count Form

VEHICLE COUNT SHEET NUMBER
DATE START TIME FINISH TIME

		CODING
1 PEDAL CYCLES	TOTAL	
2 MOTOR CYCLES	TOTAL	
3 LIGHT GOODS VEHICLES	TOTAL	
4 CARS	TOTAL	
5 GOODS VEHICLES RIGID 2 AXLE	TOTAL	
6 GOODS VEHICLES 3 AXLES	TOTAL	
7 GOODS VEHICLES 4 AXLES+	TOTAL	
8 BUSES AND COACHES	TOTAL	

Pedestrian Behaviour Record Form

DAY____________SHEET NUMBER__________

AGE				
SEX				
WALKING SITUATION				
TIME OF CROSSING				
MODE OF APPROACH				
DELAY				
DELAY POSITION				
BEHIND PARKED VEH				
NO. PARKED VEHICLES				
MODE OF CROSS				
ANGLE OF CROSS				
ACCEPT GAP				
SPEED				
TRAFF.FLOW				
DELAY CENTRE				
MODE OF CROSS				
ANGLE OF CROSS				
ACCEPT GAP				
SPEED				
TRAFF.FLOW				
TOT.CROSS TIME				
DESTIN-ATION				

CROSSING BEHAVIOUR CODING FOR VIDEO ANALYSIS.

1) Sex 1=Male 2=Female
2) Age 1=Under 18 2=18-65 3=Over 65
3) Walking situation 1=Alone 2=Accompanied
4) Time of crossing
5) Mode of approach 1=Walk 2=Run
6) Delay at kerb
7) Position of delay 1=gutter of road not on the pavement
   2=on the pavement
   3=shelter of offside of parked vehicle
   4=in effective carriageway within 2m of offside of the parked car
   5=no delay
8) Behind parked vehicle 1=Yes 2=No
9) Number of parked vehicles (Number)
10) Mode of crossing 1=Walk 2=Run
11) Angle of crossing
12) Acceptance gap
13) Speed of oncoming vehicle
14) Traffic flow at time of crossing (definition 15 seconds either side of actual crossing time) give indicator of traffic environment at this time.
19) Delay in centre
20) Mode of crossing 1=Walk 2=Run
21) Angle of crossing
22) Acceptance gap
23) Speed of oncoming vehicle
24) Traffic flow at time of crossing
25) Total crossing time
26) Crossing destination 1=Bus stop
   2=Shops directly opposite
   3=Walk through section
   4=Parked car

APPENDIX 2
ACCIDENT DATA

ACCIDENT DATA

Previous studies of the accident problem on radial routes have highlighted the safety problem on these categories of roads especially where the adjacent landuse is retail (Chapman, 1978; McQuigan, 1982; Silcock and Worsey, 1982; Lawson, 1985). Chapman (1978) and Lawson (1985), in particular, highlight the pedestrian casualty problem on radial routes, especially where the adjacent landuse is predominantly retail. Yet none of these studies has studied the nature of pedestrian casualties which occur on tenemental radial routes.

For this study, pedestrian casualty data for the whole of central Edinburgh, obtained from STATS 19 data, was made available by Lothian Regional Council. The definition of the central area in this case corresponding to the local plan boundary which has been "widely drawn to include both the city centre and the adjacent housing areas, dating mainly from before 1914 and typified by stone built tenemental districts and villa suburbs" (City of Edinburgh District Council, 1991, P10). The data base in turn was disaggregated into two subsets; one of pedestrian casualties occurring on tenemental streets which have the desired qualities of being of a mixed retail/residential nature and of being located on a radial route; and the second, of pedestrian casualties occurring on other, predominantly residential streets. Casualties in the central business core area were excluded from both these subsets (see figure 3.1 in chapter 3). The requirement for aggregate pedestrian road casualty data by street category was necessary because the numbers of casualties on a 100 metre section of street are not sufficient to permit meaningful analysis. The aggregate data, by street type, reflects sufficiently the different traffic and pedestrian activity patterns which occur on tenemental-radial routes and other predominantly residential streets. It should be noted that the casualty data is likely to be under reporting the actual number of pedestrian casualties occurring throughout.

In 1990, the number of pedestrian casualties occurring in Edinburgh's Central Local Plan area as a whole, accounted for 15.6% (423) of all pedestrian casualties in the whole of Edinburgh. For the central local plan area only, in 1990, tenemental-radial routes accounted for 34.5% (146) of pedestrian casualties, compared to a higher proportion of 41.4% in the central business core and 24.1% in other street types. These figures can be explained as a function of the density of the built-up area and the greater pedestrian/vehicle conflict which occurs in areas where the intensity of activity is greater. The following analysis and discussion which relates to the differences in casualty characteristics between tenemental-radial routes and other streets refers to pedestrian casualty data for the period January 1987 to February 1991.

Age, sex and severity characteristics

In central Edinburgh, a higher proportion of casualties are pedestrians on tenemental-radial routes than on other types of streets, 31% compared to 25%. However, a larger proportion of pedestrians are killed or seriously injured on other streets, 39.5% compared to 34.4% on tenemental radials, reflecting the lower congestion levels, higher speeds and the higher proportions of elderly and child pedestrians on these other predominantly residential streets (table 1). The proportion of pedestrian casualties in the 0-14 age group is relatively low in central Edinburgh (12.9% compared to 34.9% nationally in 1991) (table 2). On tenemental-radial routes, the proportion of pedestrian casualties aged 0-14 years old is lower at 13.4% compared to other streets (20%) (table 3). The higher proportion of child pedestrian casualties on other street types is reflected in the numbers of school pupils injured as pedestrians on a journey to or from school; 7.3% compared to 3.5% on tenemental-radial routes. These figures reflect the use patterns where adult pedestrian activities are concentrated on tenemental-radial streets for shopping, leisure and work purposes. The proportion of elderly pedestrian casualties in central Edinburgh roughly corresponds to the national pattern (16.6% in central Edinburgh aged over 65) (table 2). As in the case of young pedestrian casualties, a higher proportion of elderly pedestrian casualties is found on other street types, 19.8% compared to 17.8% on tenemental-radials (table 3). This may in part reflect residential location patterns, with the elderly in Edinburgh tending not to live on the tenemental radial route streets, and may also reflect activity patterns and main road barrier effects on the elderly.

Time of day characteristics for both tenemental-radials and other street types are in line with national data trends, with peaks in pedestrian casualties occurring around 0800-0900 associated with journeys to school or work; 1200 midday to 1300 for journeys associated with lunchtime activities; 1600-1700 for journeys from school and work; and 2400-0100 associated with leisure and late night drinking (figure 1).

Table 1 Pedestrian casualties by severity and street type.

Street Type		
Severity	Other Streets	Tenemental Radial Routes
Sample Number[1]	*440* (%)	*538* (%)
Fatal	4.5	0.8
Serious	35.0	33.6
Slight	60.5	65.6
	100.0	100.0

Notes
[1] Sample number refers to number of casualties.

Table 2 Pedestrian casualties, central Edinburgh 1987-February 1991 and Scotland 1991, by age.

Age	Central Edinburgh 1987-Feb 91	Scotland 1991
Sample Number[1]	1719 (%)	1761 (%)
0-14	12.9	34.9
15-25	31.1	5.8*
26-65	39.3	25.7*
Over 65	16.6	23.6*
	100.0	100.0

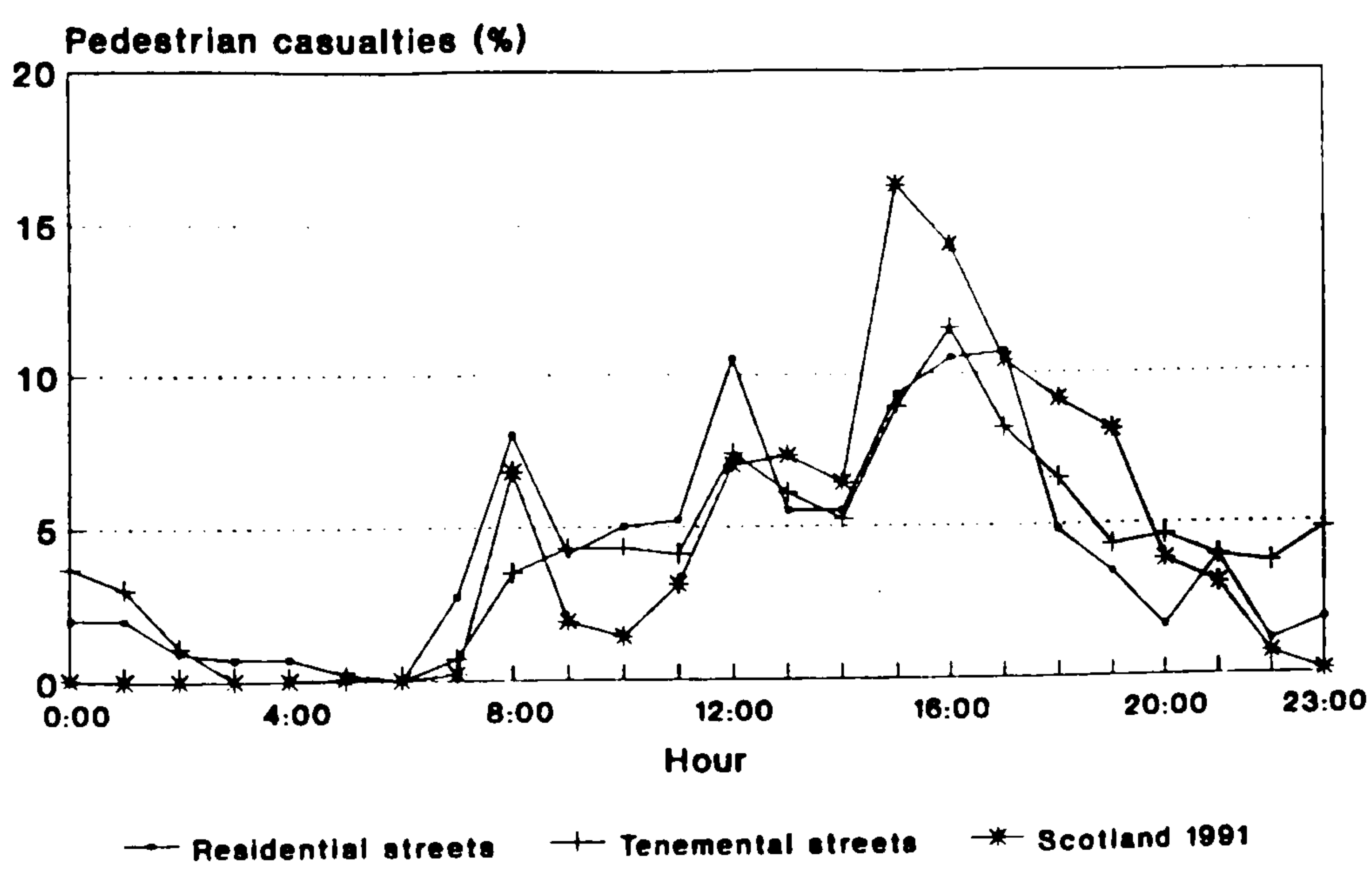
Notes
[1] Sample number refers to number of casualties.
* age groups are 15-24, 25-59, Over 59 (Scottish Office, 1992, P85).

Table 3 Pedestrian casualties by age and street type.

Street Type		
Age	Other Streets	Tenemental Radial Routes
Sample Number[1]	*440* (%)	*538* (%)
0-14	20.0	13.4
15-25	25.5	29.6
26-65	34.8	39.2
Over 65	19.8	17.8
	100.0	100.0

Notes
[1] Sample number refers to number of casualties.

Figure 1 Pedestrian casualties by street type, and Scotland, by time of day.



Notes
[1] Other streets sample size 440 (Lothian Regional Council, 1991).
[2] Tenemental radial routes sample size 538 (Lothian Regional Council, 1991).
[3] Scotland sample size 2073 (Scottish Office, 1992, P91).

Pedestrian casualties at junctions

The majority of pedestrian casualties occur at or within 20 metres of junctions: in higher proportion on tenemental-radial streets (74.5%) compared to other streets (63.4%). This pattern may reflect the more formalised street crossing behaviour and reduced crossing opportunities for pedestrians on main traffic routes, due to the combined effects of guard railing near crossing facilities and the impact of the traffic barrier effect. It may also reflect a higher number of junctions on other predominantly residential streets. The proportion of pedestrian casualties on tenemental-radials at automatic traffic signals is greater (29.2% compared to 11.1%) while on other streets a higher proportion is recorded at uncontrolled junctions (36.6% compared to 7.1%) (table 4). This is as expected, again reflecting the formalisation of traffic controls on the radial routes.

Table 4 Pedestrian casualties by street and junction control type.

Junction Control	**Other Streets**	**Tenemental Radial Routes**
Sample Number[1]	*440* (%)	*538* (%)
Not at Junction	**36.6**	**25.5**
Automatic Traffic Signal	**11.1**	**29.2**
Stop Sign	**0.7**	**0.6**
Give-Way	**42.0**	**37.7**
Uncontrolled	**9.5**	**7.1**
	100.0	**100.0**

Note
[1] **Sample number refers to number of casualties.**

Junctions controlled by giveway signs or markings account for the largest proportions of pedestrian casualties on both tenemental-radials (37.7%) and on other streets (42%). The proportion of pedestrians seriously injured at such junctions is also greater, accounting for 45% of pedestrians seriously injured on tenemental radials and 37.9% of those seriously injured on other street types (table 5a and b).

Table 5a Pedestrian casualties on other streets, by severity and junction control.

Pedestrian Casualties (%)		
Junction Control	**Serious**	**Slight**
Sample Number[1]	140 (%)	236 (%)
Not at Junction	41.4	36.0
Automatic Traffic Signal	11.4	11.9
Give-Way	37.9	41.5
Uncontrolled	9.3	10.6

Note
[1] Sample number refers to number of casualties.

Table 5b Pedestrian casualties on tenemental-radial routes, by severity and junction control.

Pedestrian Casualties (%)		
Junction Control	**Serious**	**Slight**
Sample Number[1]	*180* (%)	*351* (%)
Not at Junction	22.8	27.3
Automatic Traffic Signal	25.5	30.5
Give-Way	45.0	34.8
Uncontrolled	6.7	7.4

Note
[1] Sample number refers to number of casualties.

Pedestrian casualties and crossing facilities

On both tenemental-radial routes and other street types, a high proportion of pedestrian casualties occur where no crossing facilities are within 50 metres, 44.1% in the case of tenemental-radial routes and 70% on other street types. In both data sets, substantial proportions of pedestrian casualties occur at crossing sites controlled by school crossing patrols (33.4% on tenemental radials and 12.5% on other streets); reflecting the fact that patrols are allocated to the most dangerous crossing points (table 6). Structural factors again make substantial contributions to the patterns of accidents in relation to crossing facilities. For instance, smaller numbers of pedestrian casualties on tenemental-radials occur at junctions where there are no crossing facilities, 45.2% compared to 73.1% on other streets.

Table 6 Pedestrian casualties by crossing facility and street type.

Crossing Facility	Other Streets	Tenemental-Radial Routes
Sample Number[1]	*440* (%)	*538* (%)
No Crossing within 50 Metres	70.0	44.1
Zebra	0.2	0.2
Pelican	4.1	7.4
Other Light Controlled Crossing	10.7	13.2
School Crossing Patrol	12.5	33.4
Authorised Person	0.5	0.4
Footbridge/Subway	2.0	1.3
	100.0	100.0

Note
[1] **Sample number refers to number of casualties.**
Data provided in this table is different to that in table 7 due to differences in coding criteria as stipulated by the Department of Transport (DTp, 1990c).

Pedestrian crossing movement and location

On both tenemental-radial routes and other predominantly residential streets, substantial proportions of pedestrians are injured within 50 metres of crossing facilities; 30.5% of casualties on tenemental-radials and 14.1% of casualties on other streets (table 7). There is little evidence to suggest that there is a significant shift or increase in the numbers of pedestrian casualties occurring on or near to crossings in response to variations in traffic conditions with time of day, on either street type.

Table 7 Pedestrian casualties by crossing location and street type.

Pedestrian Crossing Location *Sample Number*[1]	Other Streets *440* (%)	Tenemental Radial Routes *538* (%)
On Pedestrian Crossing	9.8	17.1
In Zig-Zag Exiting Crossing	0.2	0.4
Within 50 Metres of Pedestrian Crossing	14.1	30.5
In Carrigeway Crossing Elsewhere	62.7	40.9
Footway/Verge	4.8	5.0
Refuge/Island	0.5	0.9
Centre of Carriageway	0.5	0.0
In Carriageway Not Crossing	7.5	5.2
	100.0	100.0

Note
[1] **Sample number refers to number of casualties.**

On both types of streets, large proportions of pedestrian casualties occur at unmasked crossing locations, with much smaller proportions recorded at masked crossing locations; that is, at a location where there is no concealment recorded from a parked or stationary vehicle (tenemental-radials 74.8% unmasked and 15.1% masked; other streets 72.5% unmasked and 14.5% masked). Video analysis revealed that 61% of all analysed crossings on the case study tenemental-radials were made from behind parked vehicles. It would therefore seem that masking by parked vehicles is not a significant factor in terms of pedestrian casualties, given the levels of crossing activity. However there could be some under-reporting of masking due to the subjective judgements of the Police at the accident scene. Nonetheless this is unlikely to account for such a wide discrepancy between the proportion of crossings actually occurring from behind parked vehicles and the proportion of pedestrian casualties occurring at masked locations on tenemental-radial routes.

APPENDIX 3
PEDESTRIAN FLOW DATA AND QUESTIONNAIRE SURVEY FINDINGS

Pedestrian Flow, 0800-2000 (hrs), Both Pavements, Bruntsfield Place

	Eastern Pavement		Western Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	71 (3)	66 (2)	153 (3)	174 (4)
18-65	1393 (50)	1126 (40)	2053 (42)	2172 (44)
Over 65	35 (1)	109 (4)	167 (3)	199 (4)
Total	1499	1301	2373	2545

Note
Pavement flow data in this table was used to calculate the crossing ratios in table 4.48 and 4.49 (chapter 4).

Crossing Flows, 0800-2000 (hrs), Both Pavements, Bruntsfield Place.

	Eastern Pavement		Western Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	0 (0)	6 (1)	6 (1)	6 (1)
18-65	256 (53)	211 (44)	310 (52)	236 (40)
Over 65	5 (1)	6 (1)	15 (2)	23 (4)
Total	261	223	331	265

Note
Crossing flow data in this table was used to calculate the crossing ratios in table 4.48 and 4.49 (chapter 4).

Pedestrian Flow, Tuesday, 0815-1815 (hrs), Both Pavements, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	122 (3)	192 (5)	113 (4)	120 (5)
18-65	1335 (34)	1785 (46)	891 (33)	1252 (47)
Over 65	155 (4)	331 (8)	93 (3)	226 (8)
Total	1611 (41)	2308 (59)	1097 (40)	1598 (60)

Note
Pavement flow data in this table was used to calculate the crossing ratios in table 4.48 and 4.50 (chapter 4).

Pedestrian Flow, Thursday, 0800-1815 (hrs), Both Pavements, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	161 (4)	195 (5)	177 (3)	190 (3)
18-65	1313 (34)	1711 (34)	2274 (41)	2360 (43)
Over 65	182 (5)	308 (8)	220 (4)	329 (6)
Total	1656 (43)	2214 (57)	2671 (48)	2879 (52)

Pedestrian Flow, Saturday, 0800-1815 (hrs), Both Pavements, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	177 (3)	190 (3)	147 (5)	138 (4)
18-65	2274 (41)	2360 (43)	1245 (41)	1278 (42)
Over 65	220 (4)	329 (6)	89 (3)	155 (5)
Total	2671 (48)	2879 (52)	1481 (49)	1571 (51)

Crossing Flows, 0800-1815 (hrs), Both Pavements, Tuesday, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	20 (2)	14 (1)	22 (2)	15 (1)
18-65	367 (46)	334 (42)	432 (47)	378 (41)
Over 65	23 (3)	45 (6)	22 (2)	61 (7)
Total	410	393	476	454

Note
Crossing flow data in this table was used to calculate the crossing ratios in table 4.48 and 4.50 (chapter 4).

Crossing Flows, 0800-1815 (hrs), Both Pavements, Thursday, Raeburn Place.

	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	21 (3)	31 (5)	15 (2)	11 (2)
18-65	333 (43)	293 (38)	274 (46)	262 (43)
Over 65	24 (3)	63 (8)	15 (2)	32 (5)
Total	378	387	304	305

Crossing Flows, 0800-1815 (hrs), Both Pavements, Saturday, Raeburn Place.

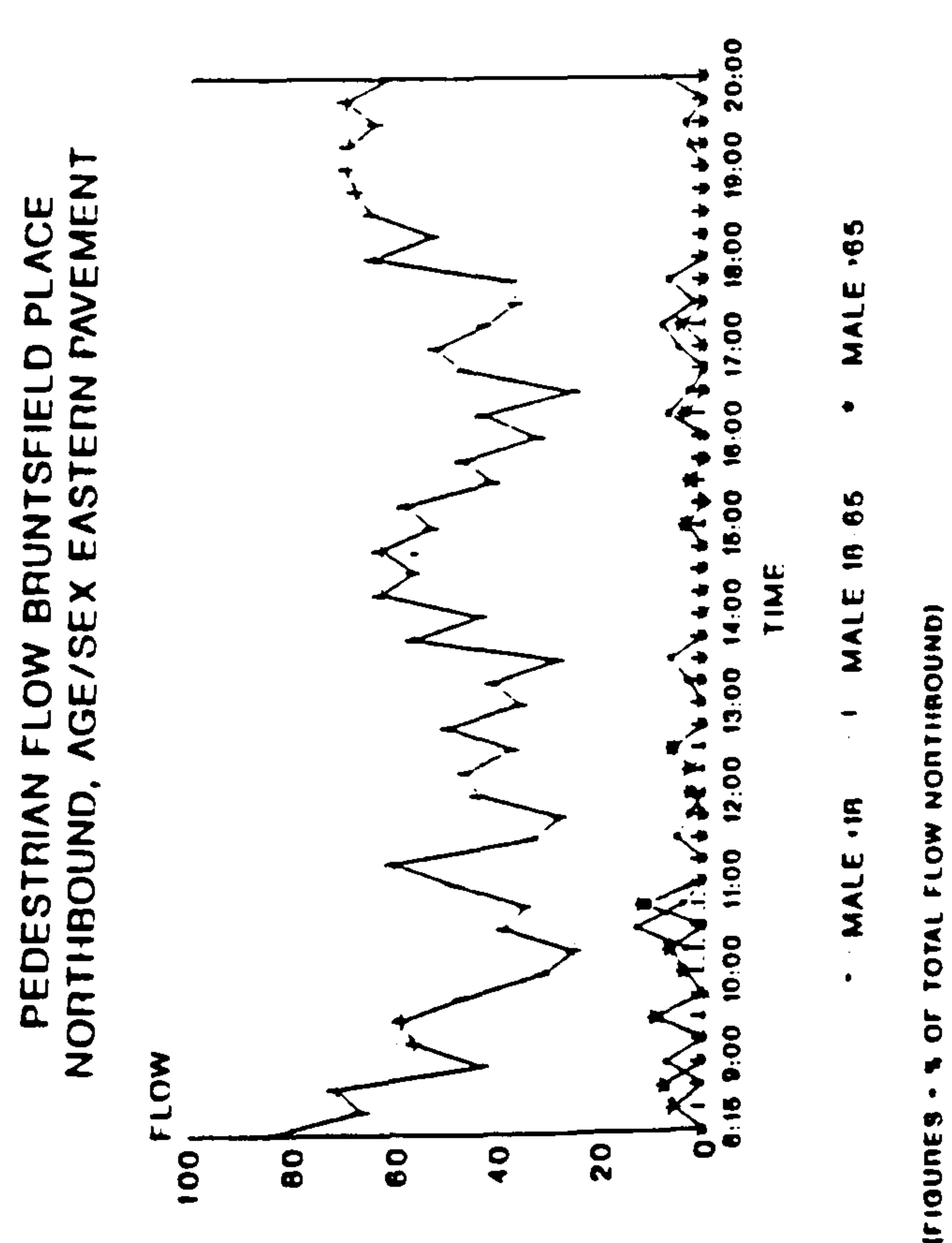
	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	24 (3)	19 (2)	26 (3)	23 (2)
18-65	422 (48)	356 (41)	484 (49)	399 (41)
Over 65	21 (2)	32 (4)	23 (2)	31 (3)
Total	467	407	533	453

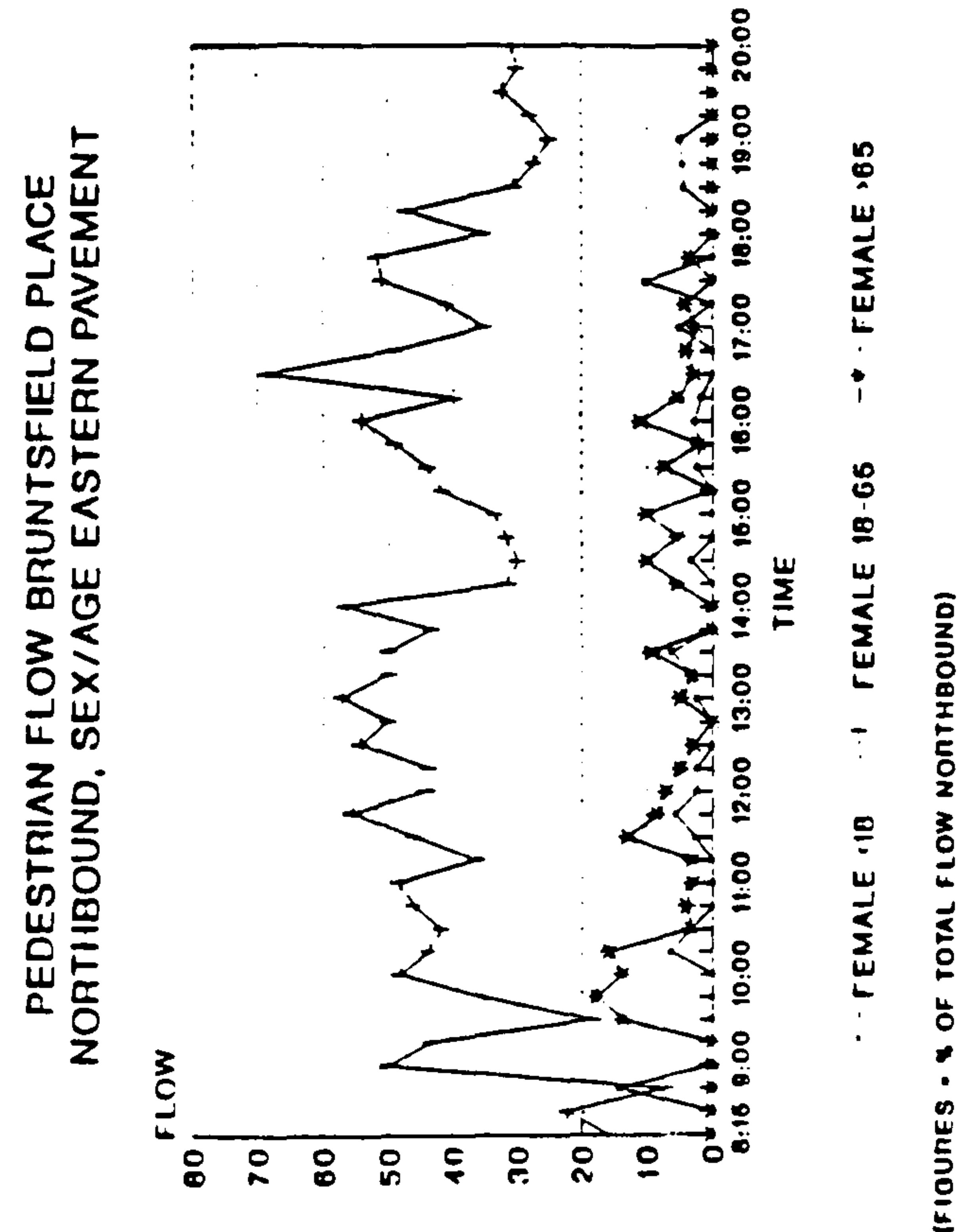
Crossing Flow 0800-1815 (hrs), at the Pelican Crossing, Tuesday, Both Pavements, Raeburn Place.

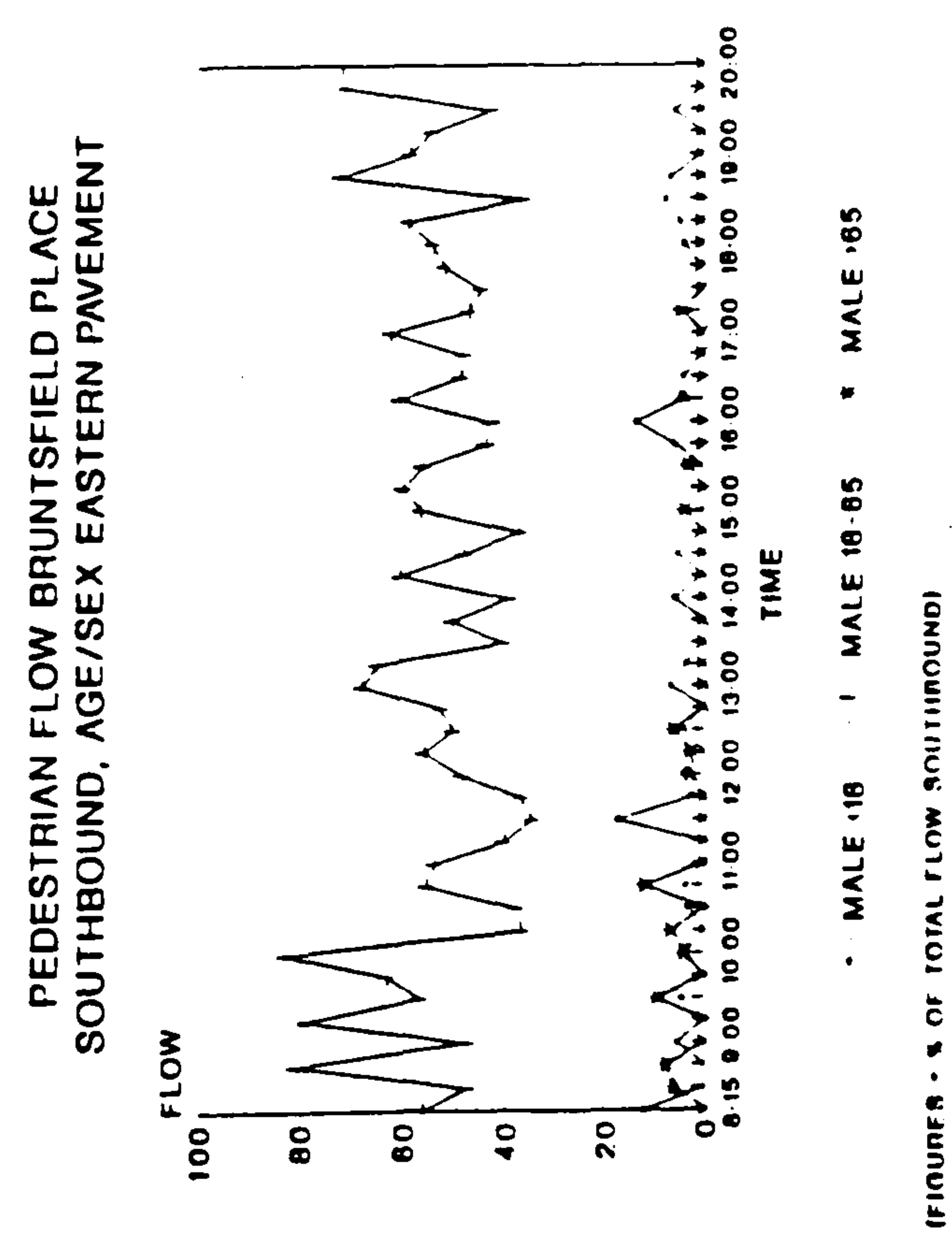
	Northern Pavement		Southern Pavement	
Age	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Under 18	35 (6)	39 (7)	48 (9)	32 (6)
18-65	100 (18)	295 (54)	116 (22)	278 (51)
Over 65	15 (3)	64 (12)	15 (3)	51 (9)
Total	150	398	179	453

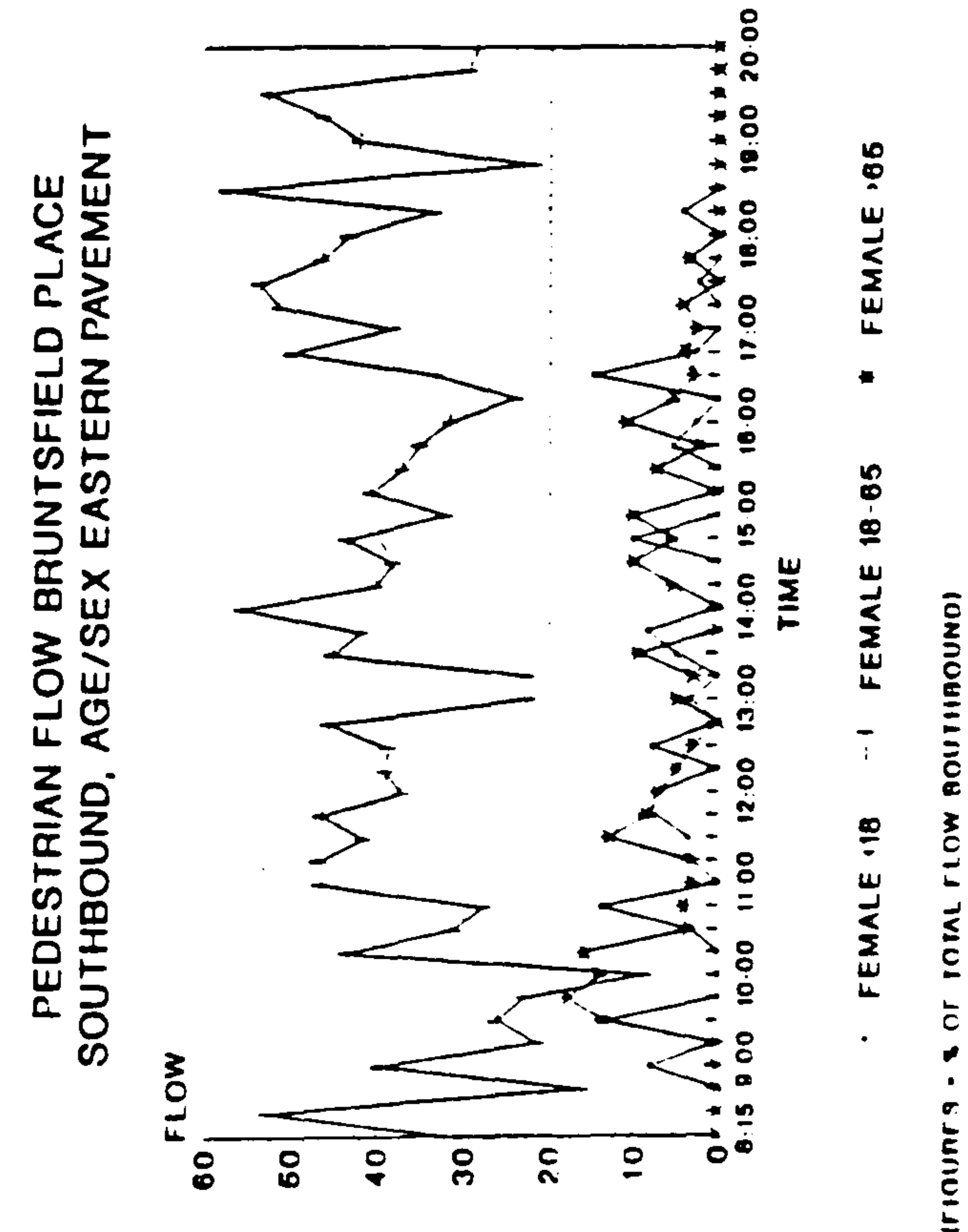
Note
Crossing flow data in this table was used to calculate the crossing ratios in table 4.50 (chapter 4).

Pedestrian Flow, Eastern Pavement, Bruntsfield Place, North and Southbound Flows, by Age and Sex.

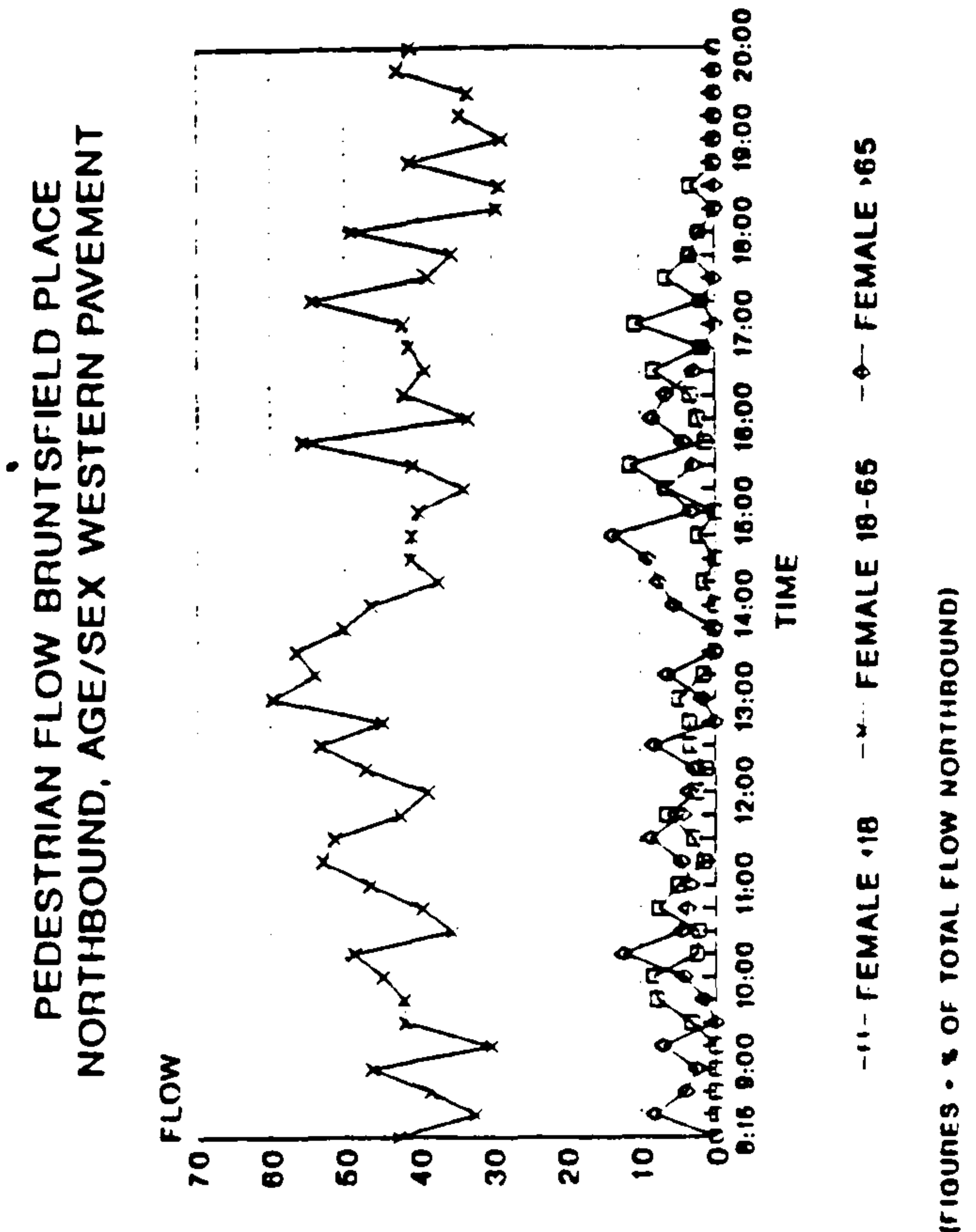


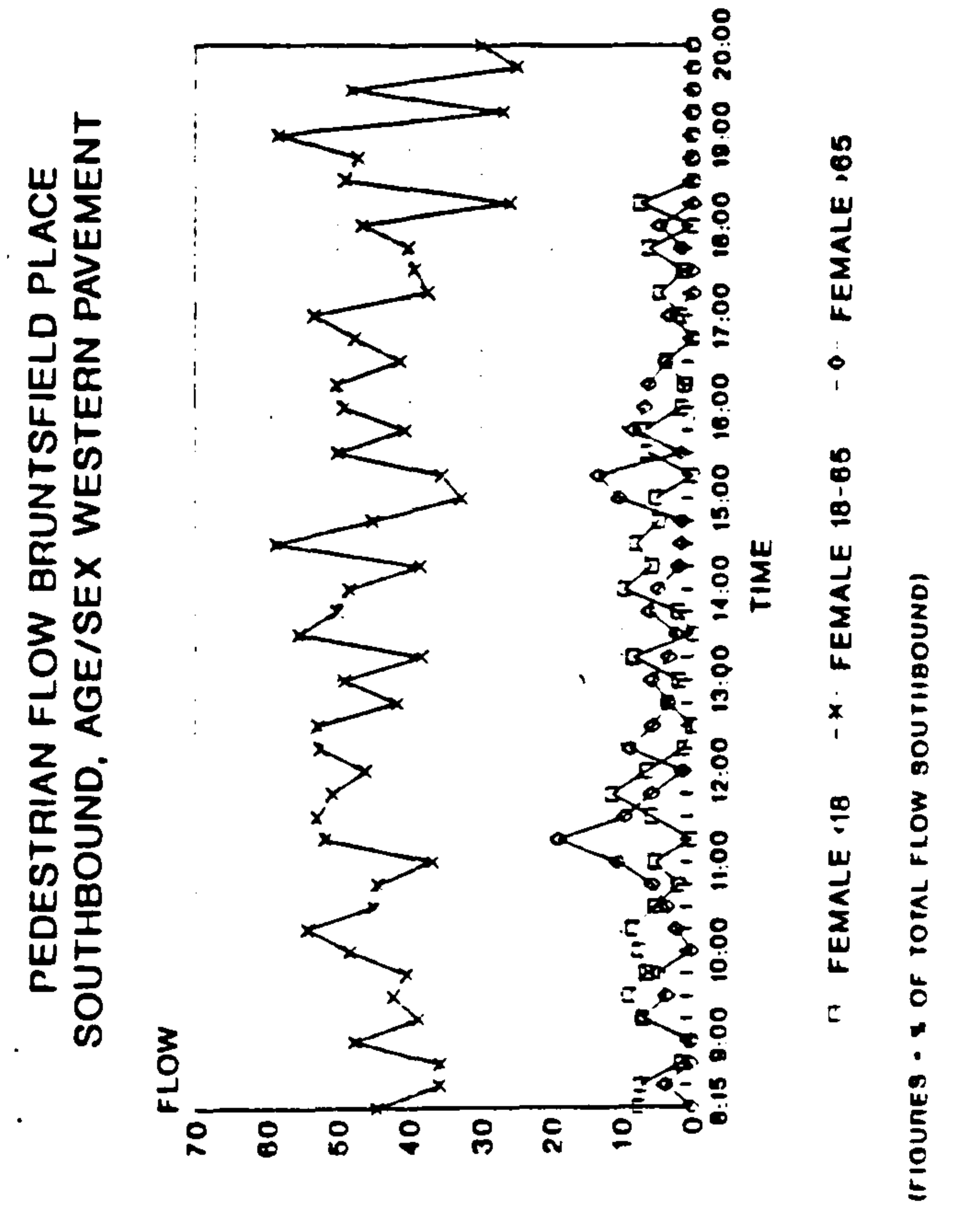


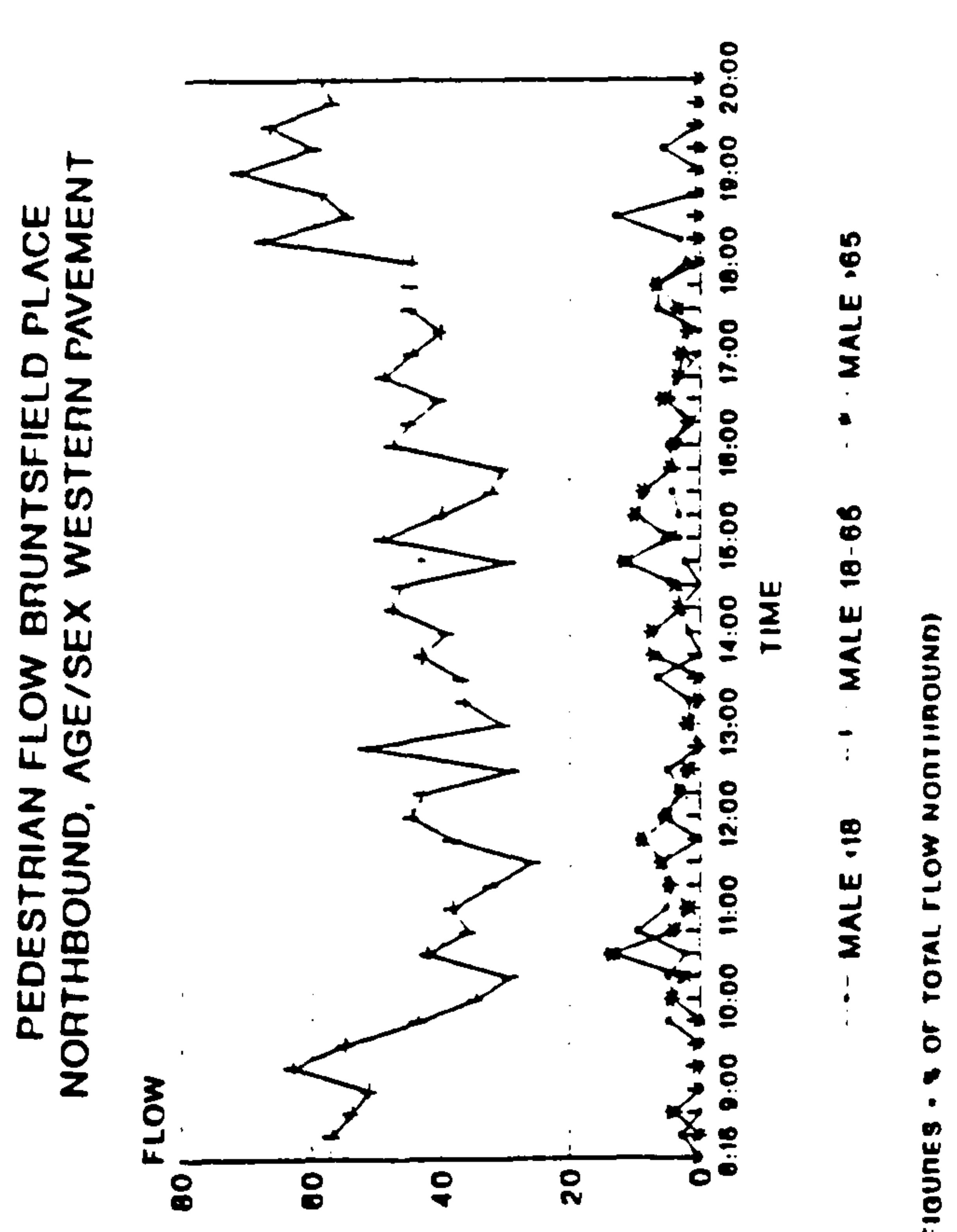


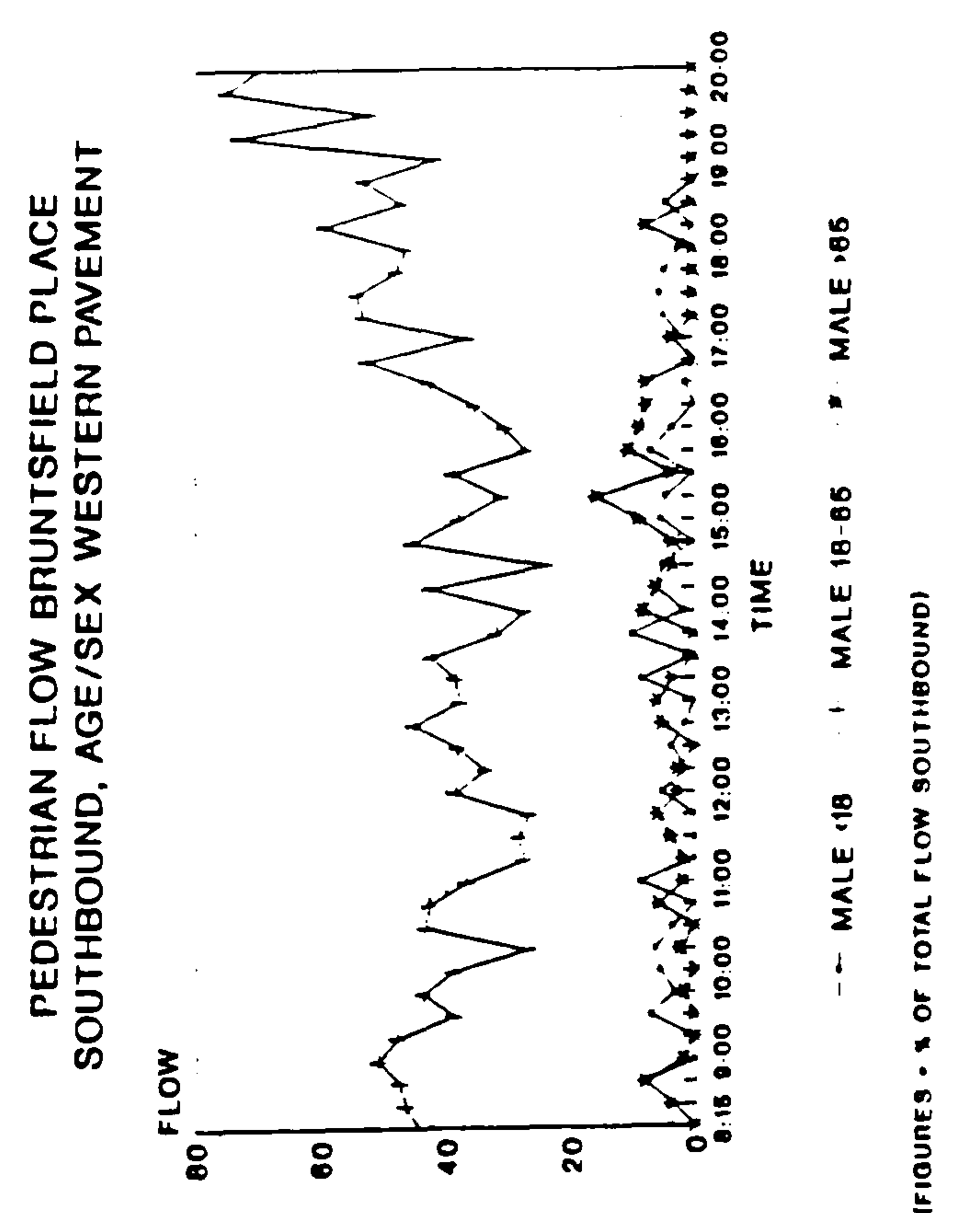


Pedestrian Flow, Western Pavement, Bruntsfield Place, by Age and Sex.

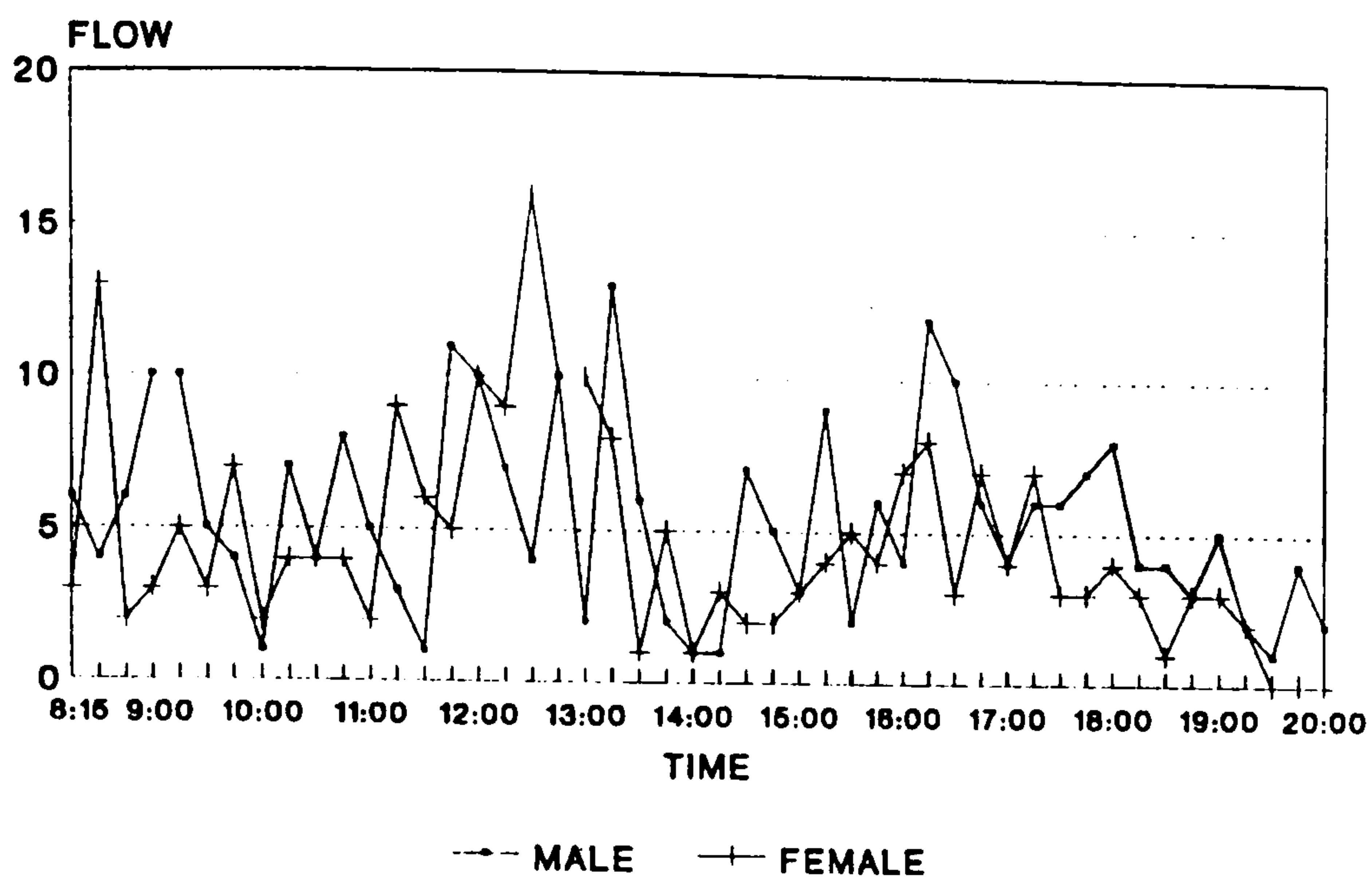




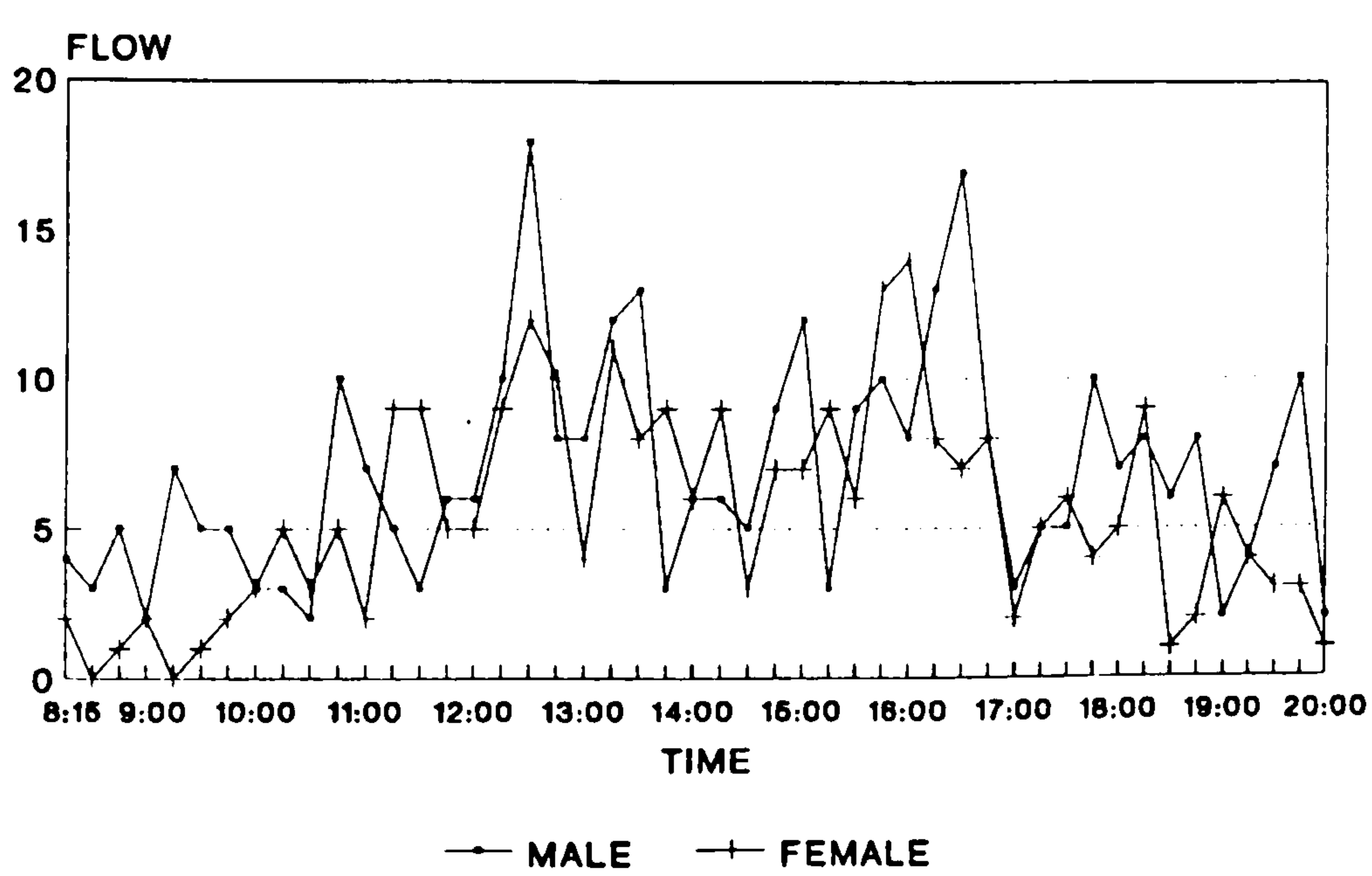




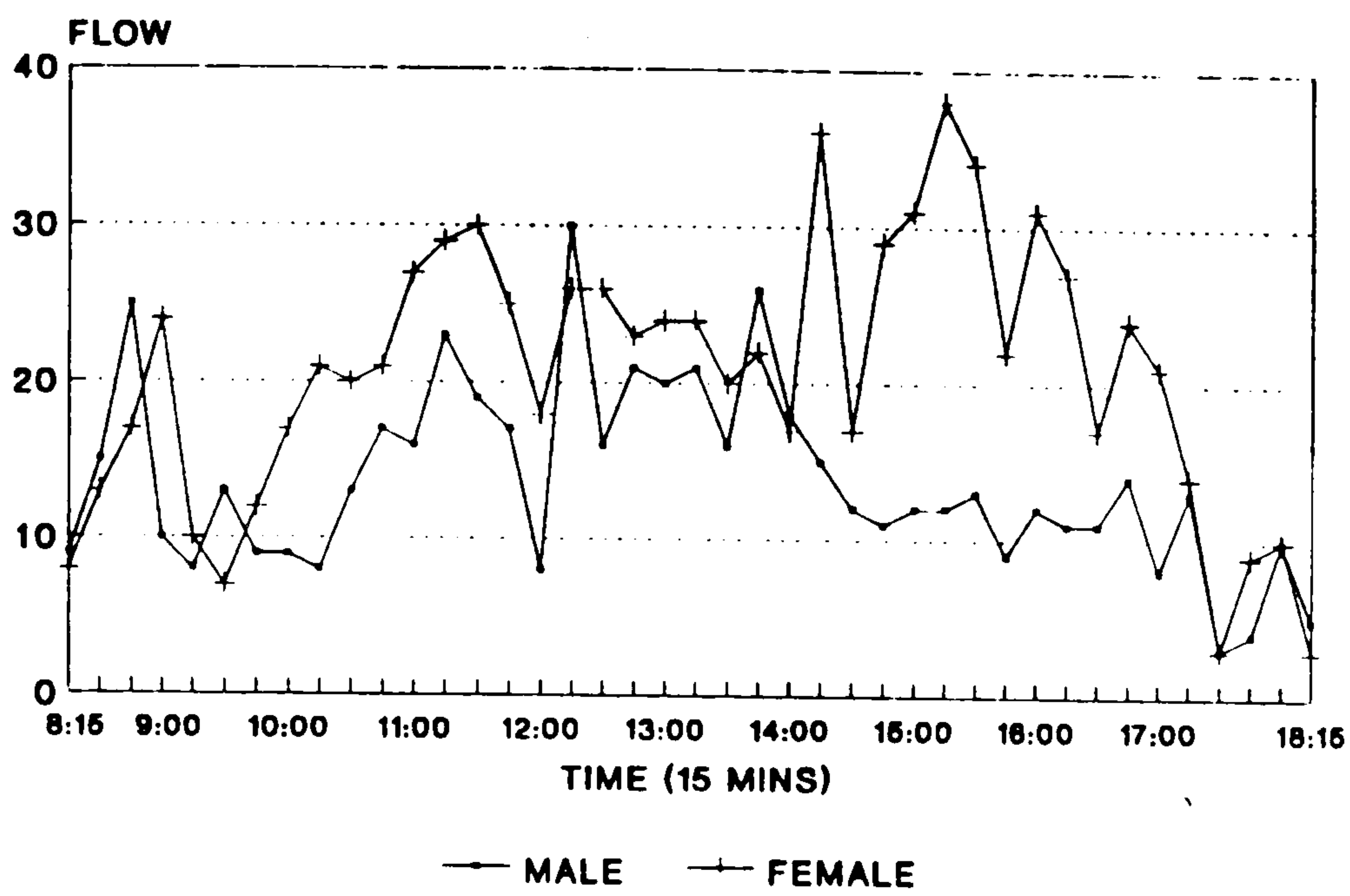
Pedestrian Crossing Flow, Eastern Pavement, Bruntsfield Place.



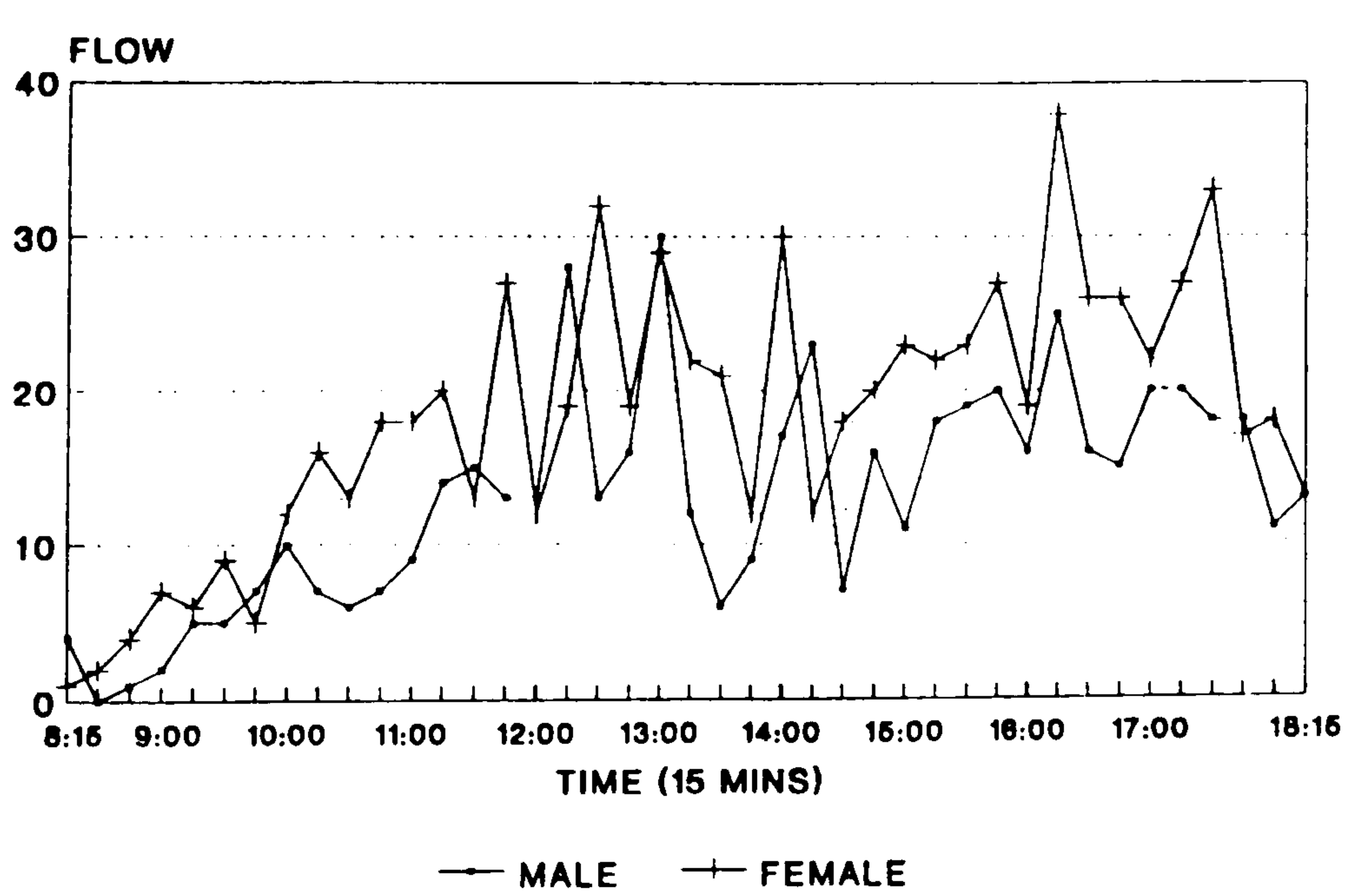
Pedestrian Crossing Flow, Western Pavement, Bruntsfield Place.



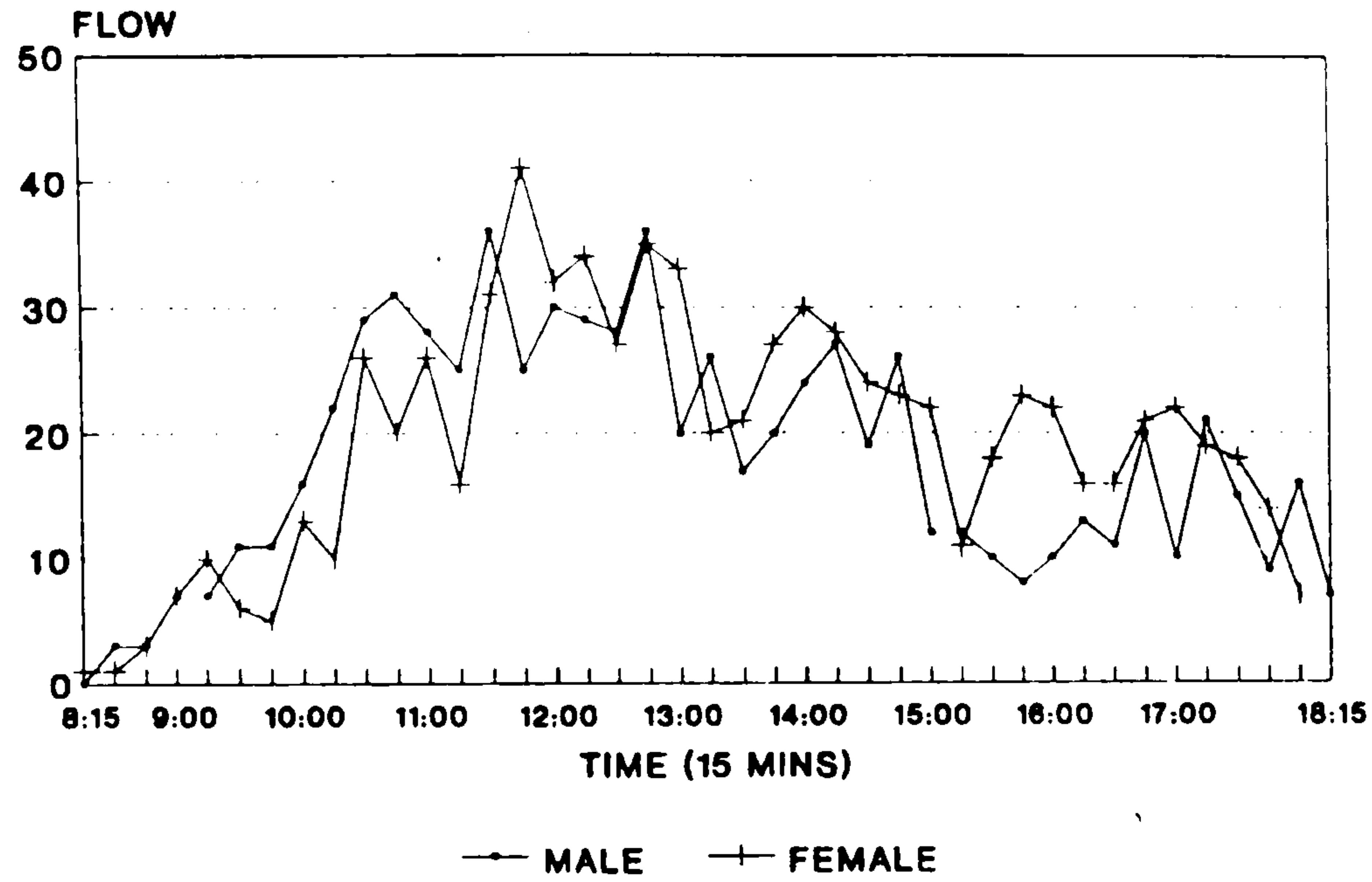
Pedestrian Flow, South Pavement, Tuesday, Eastbound Flow by Sex, Raeburn Place.



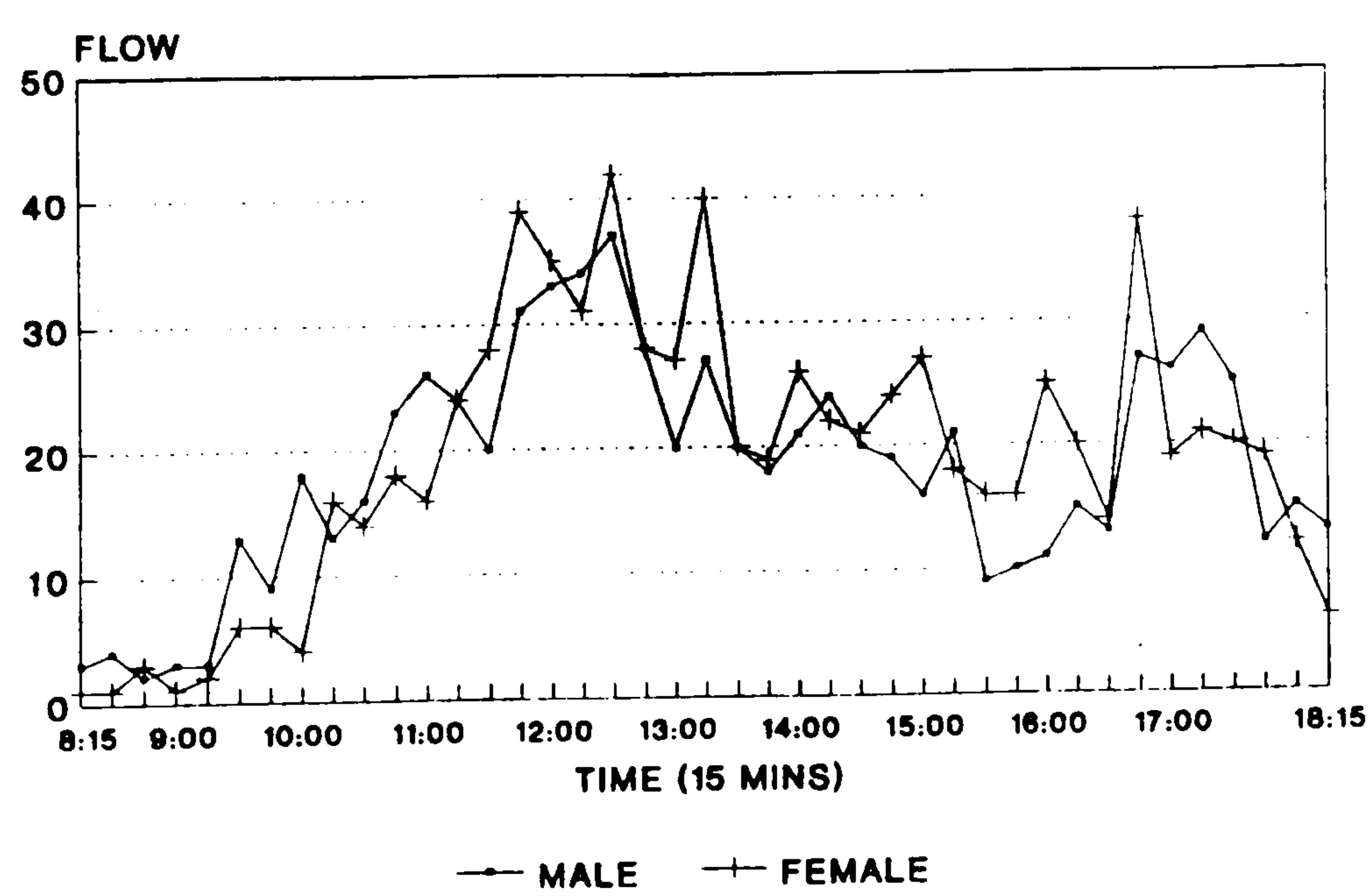
Pedestrian Flow, South Pavement, Tuesday, Westbound Flow by Sex, Raeburn Place.



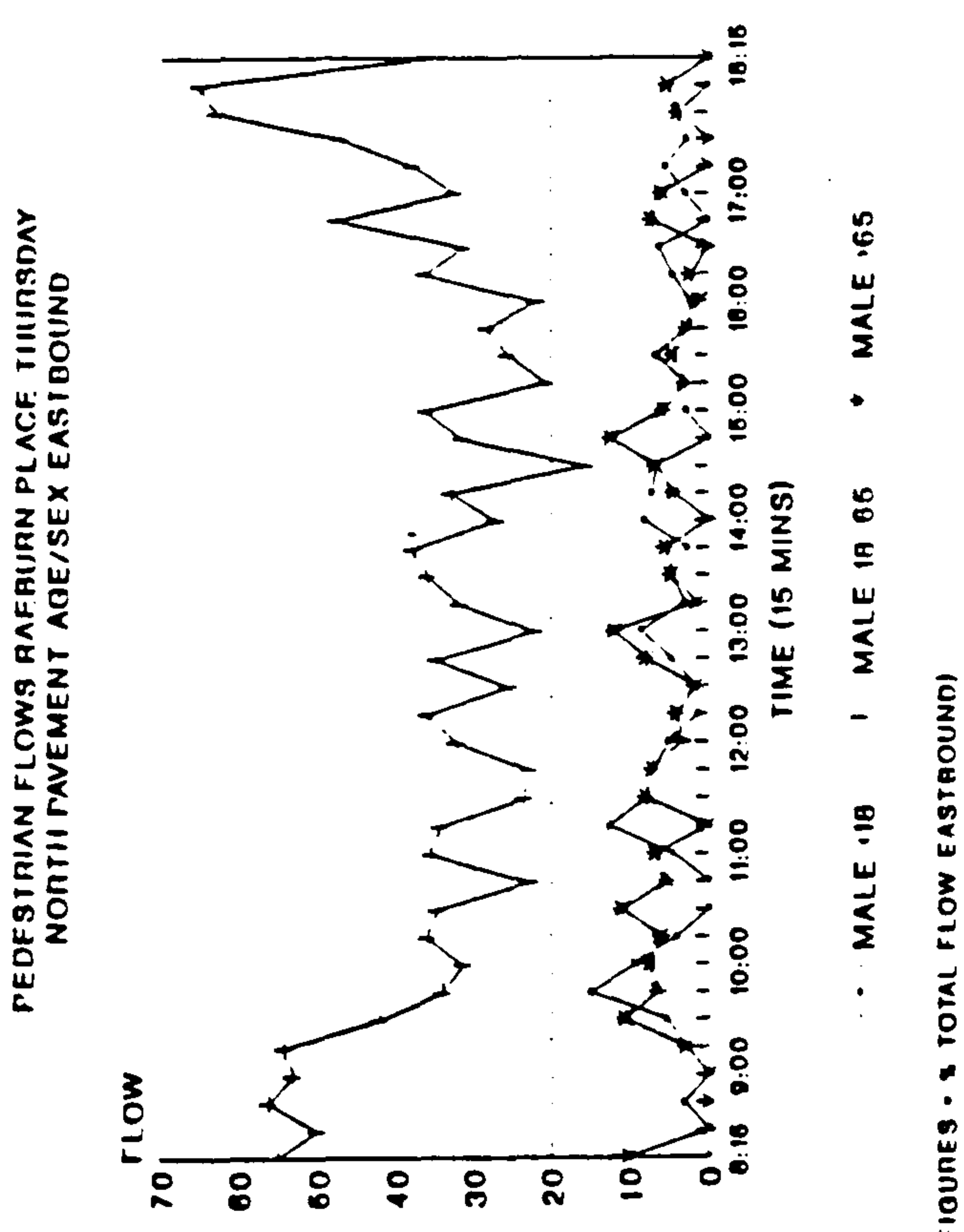
Pedestrian Flow, South Pavement, Saturday, Eastbound Flow by Sex, Raeburn Place.

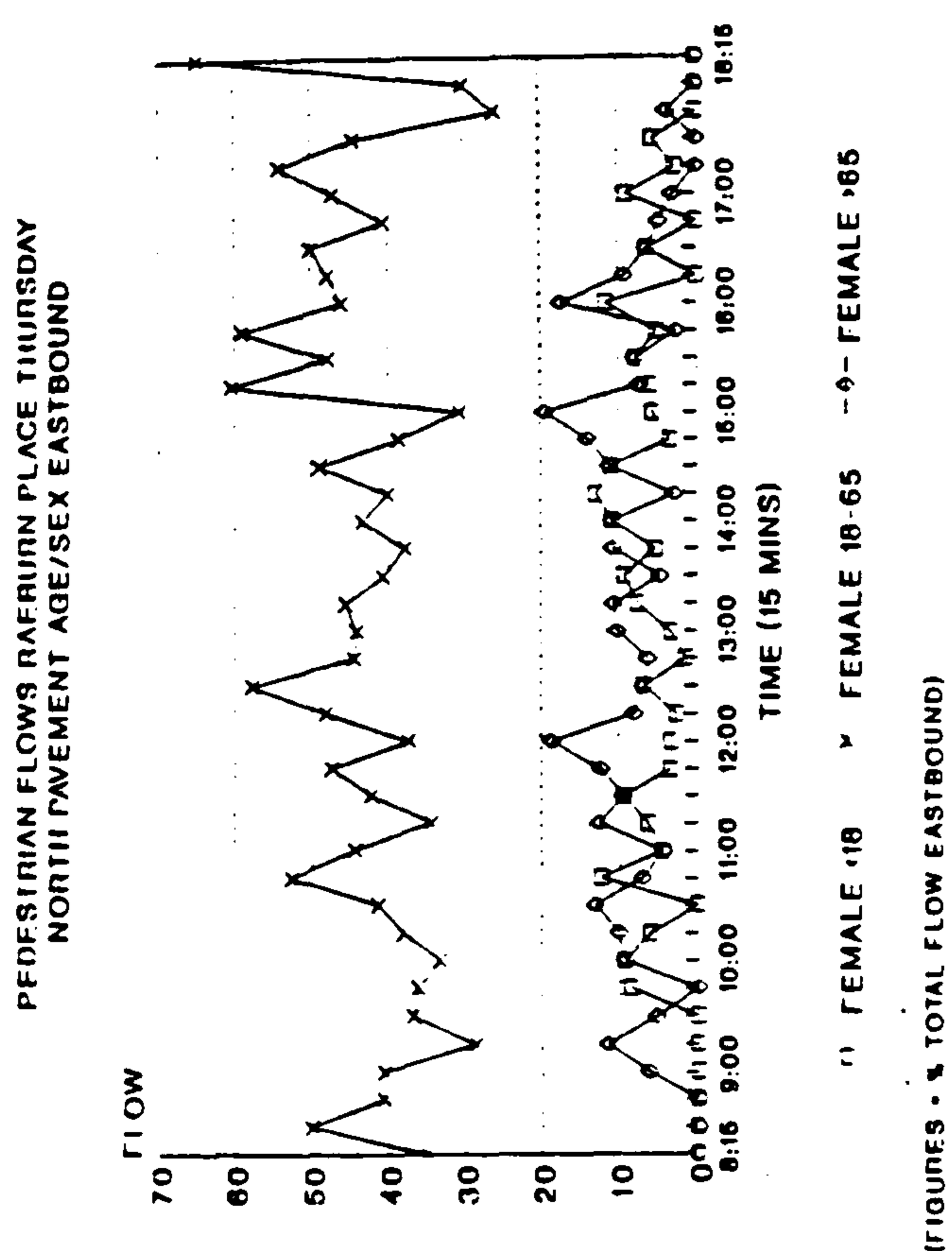


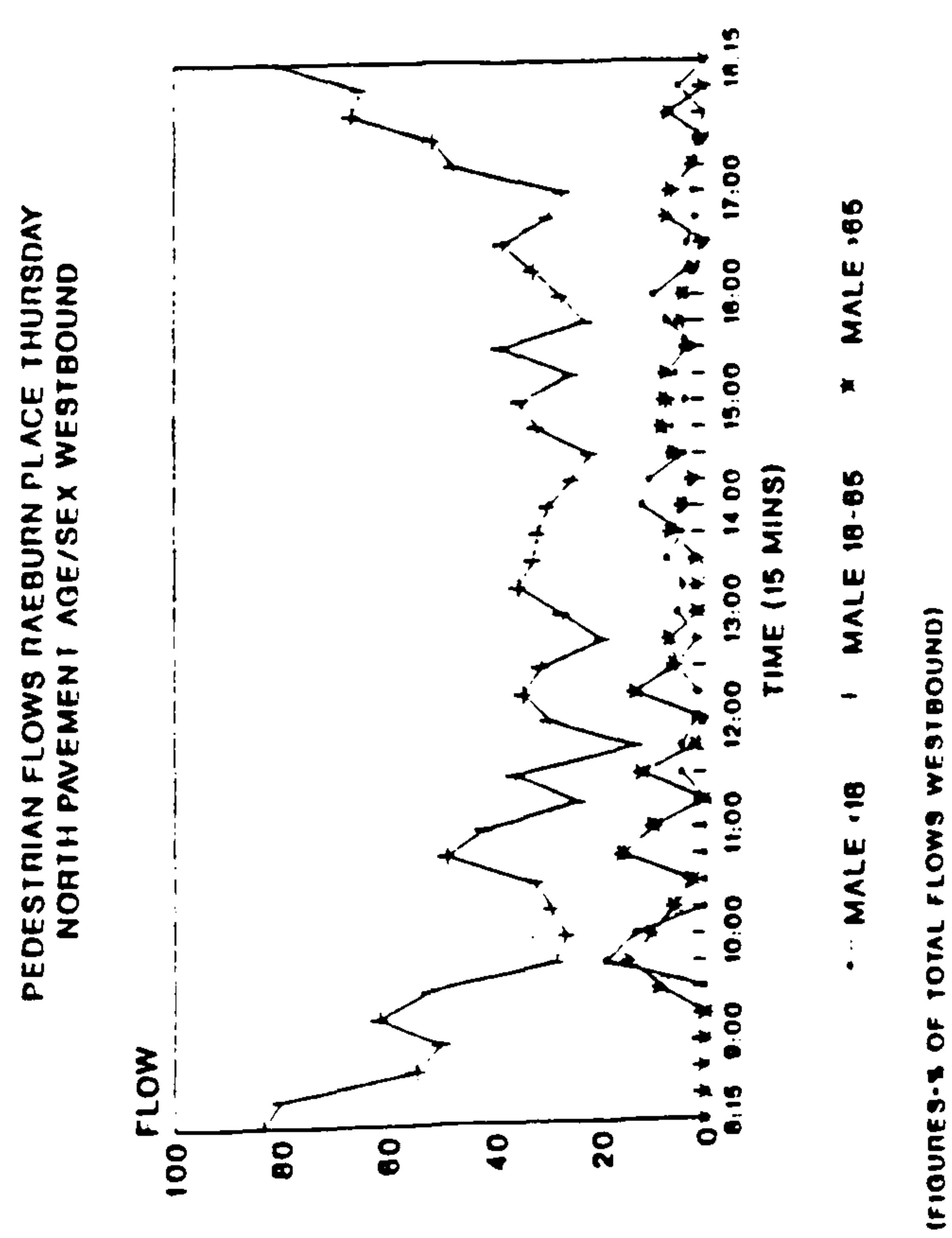
Pedestrian Flow, South Pavement, Saturday, Westbound Flow by Sex, Raeburn Place.

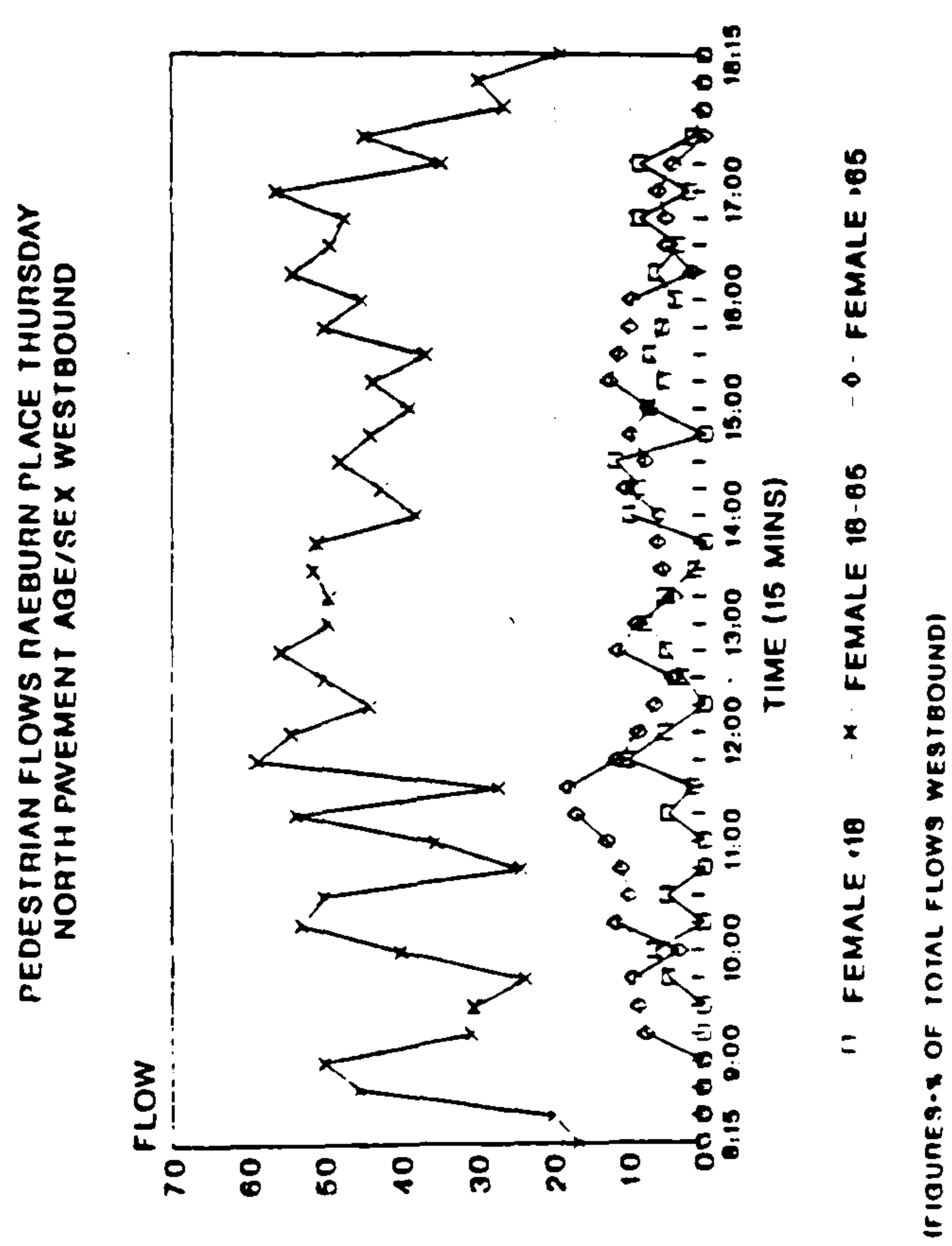


Pedestrian Flow, Northern Pavement, Thursday, by Age and Sex, Raeburn Place.

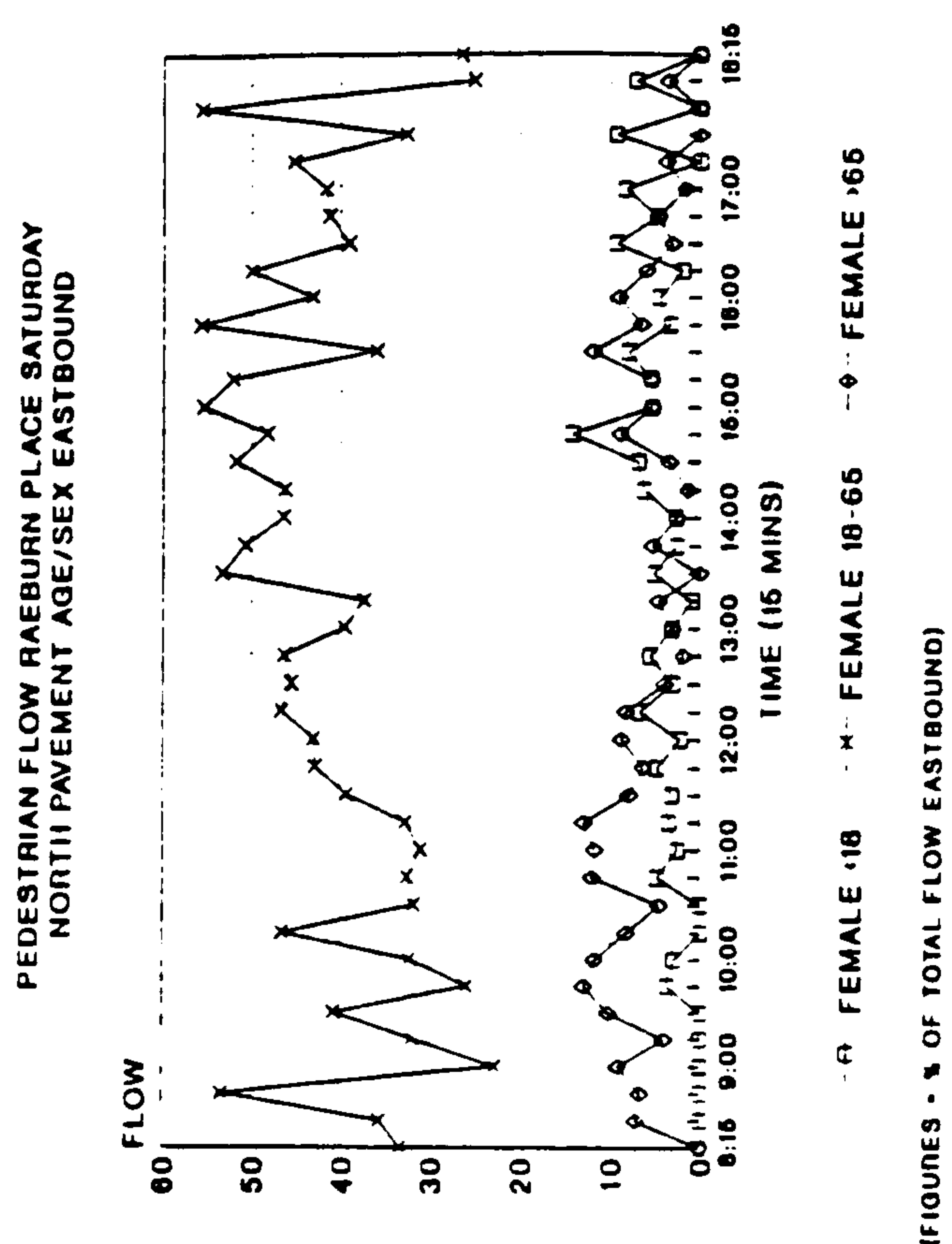


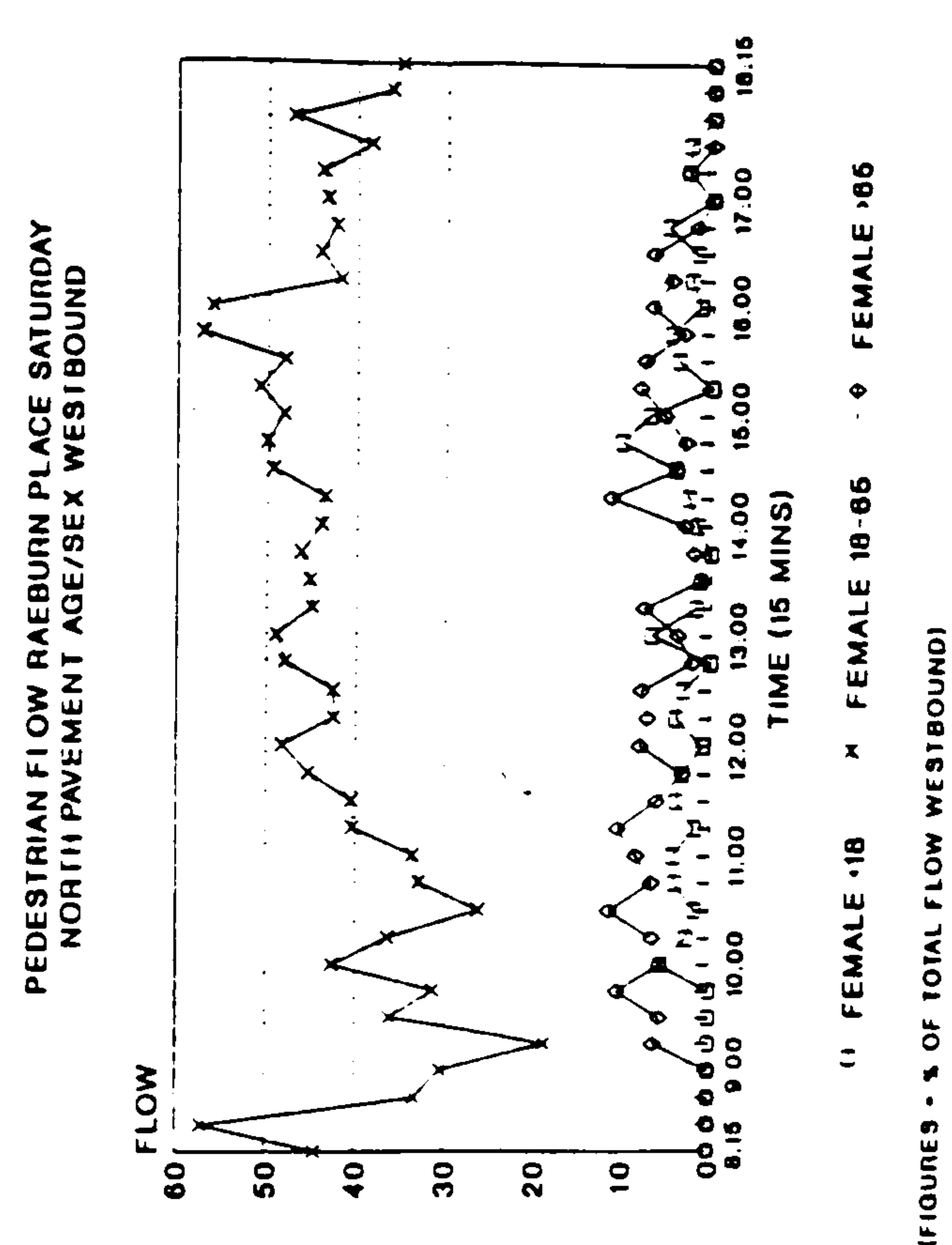


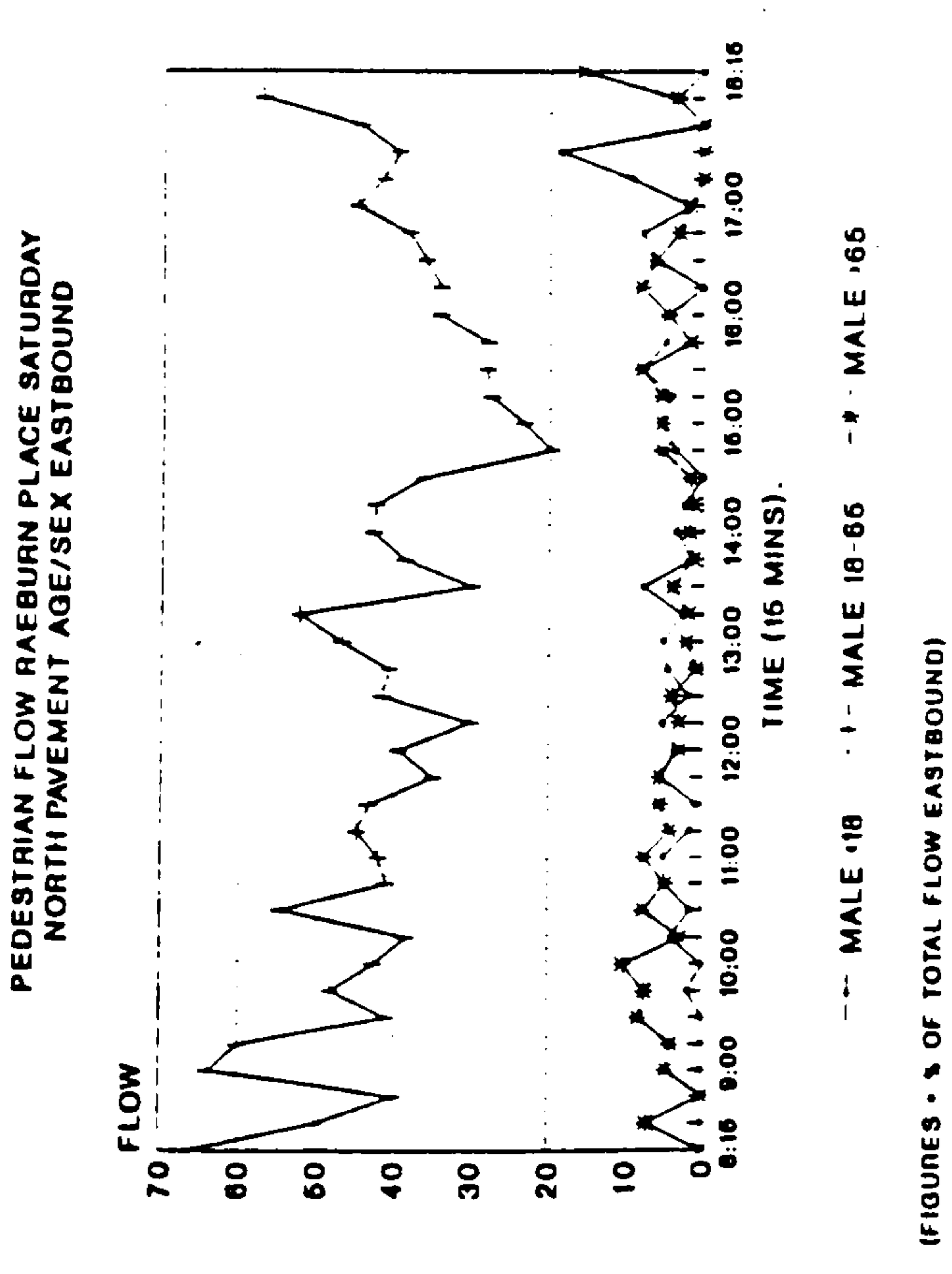


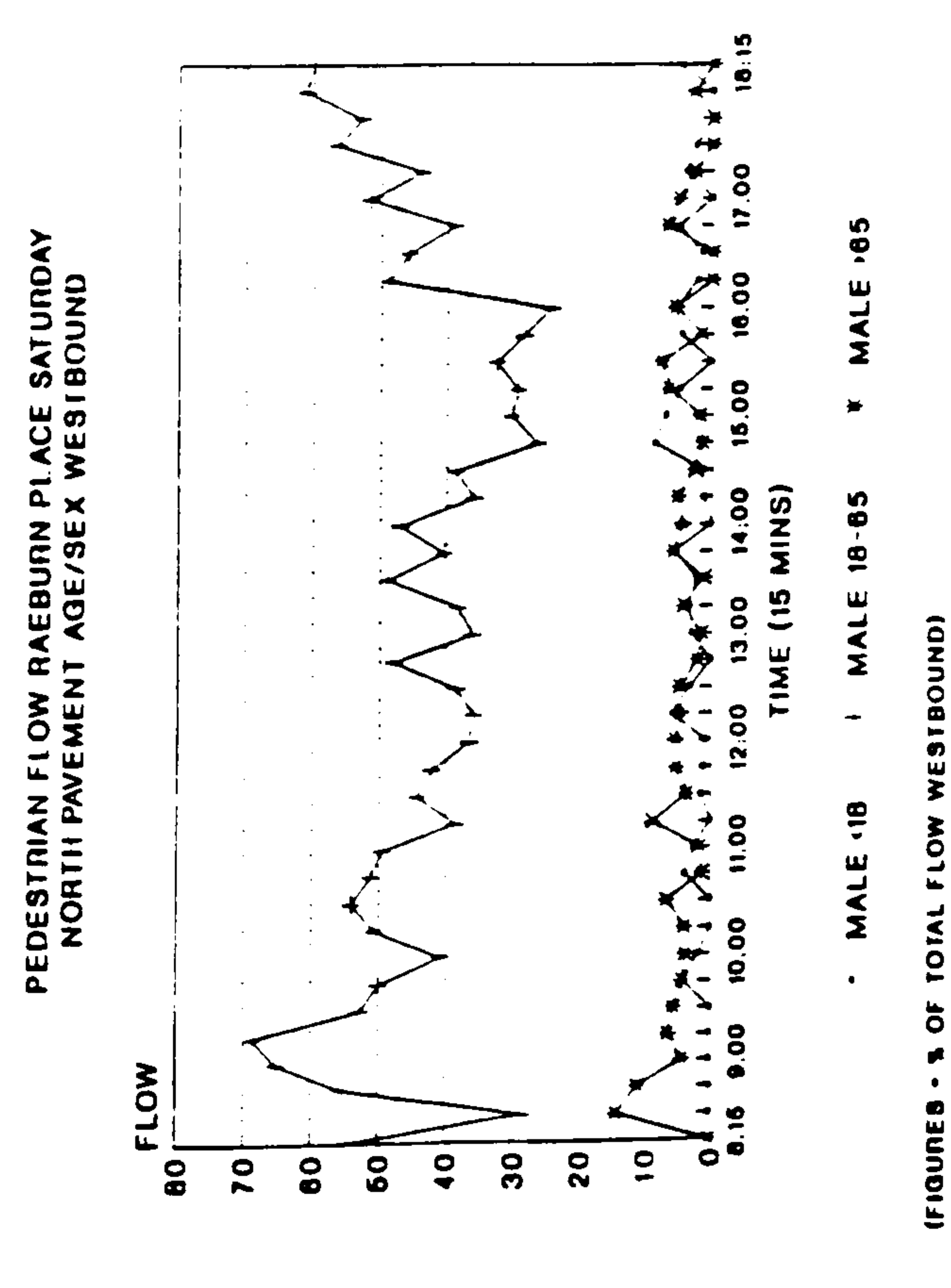


Pedestrian Flow, Northern Pavement, Saturday, by Age and Sex, Raeburn Place.

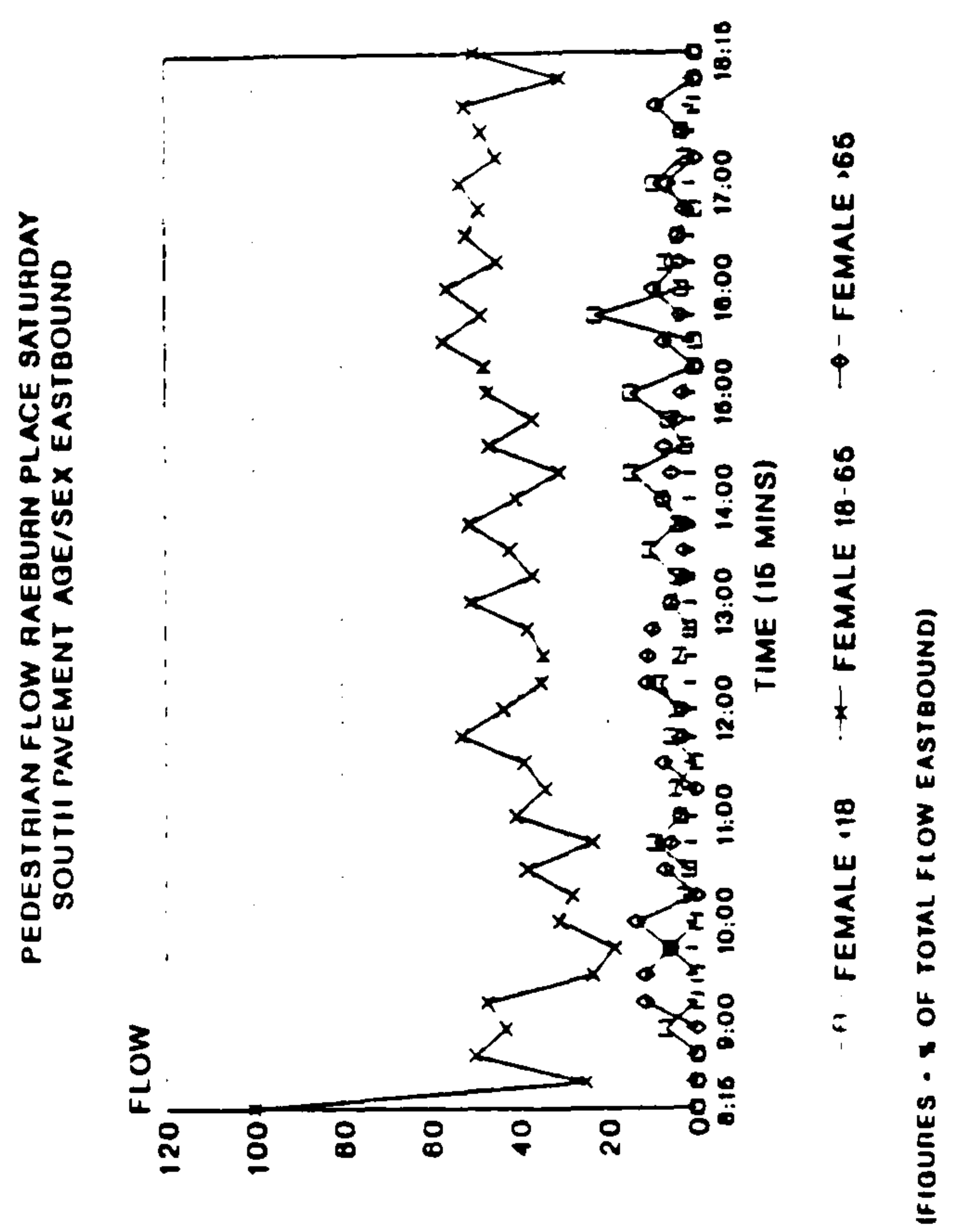


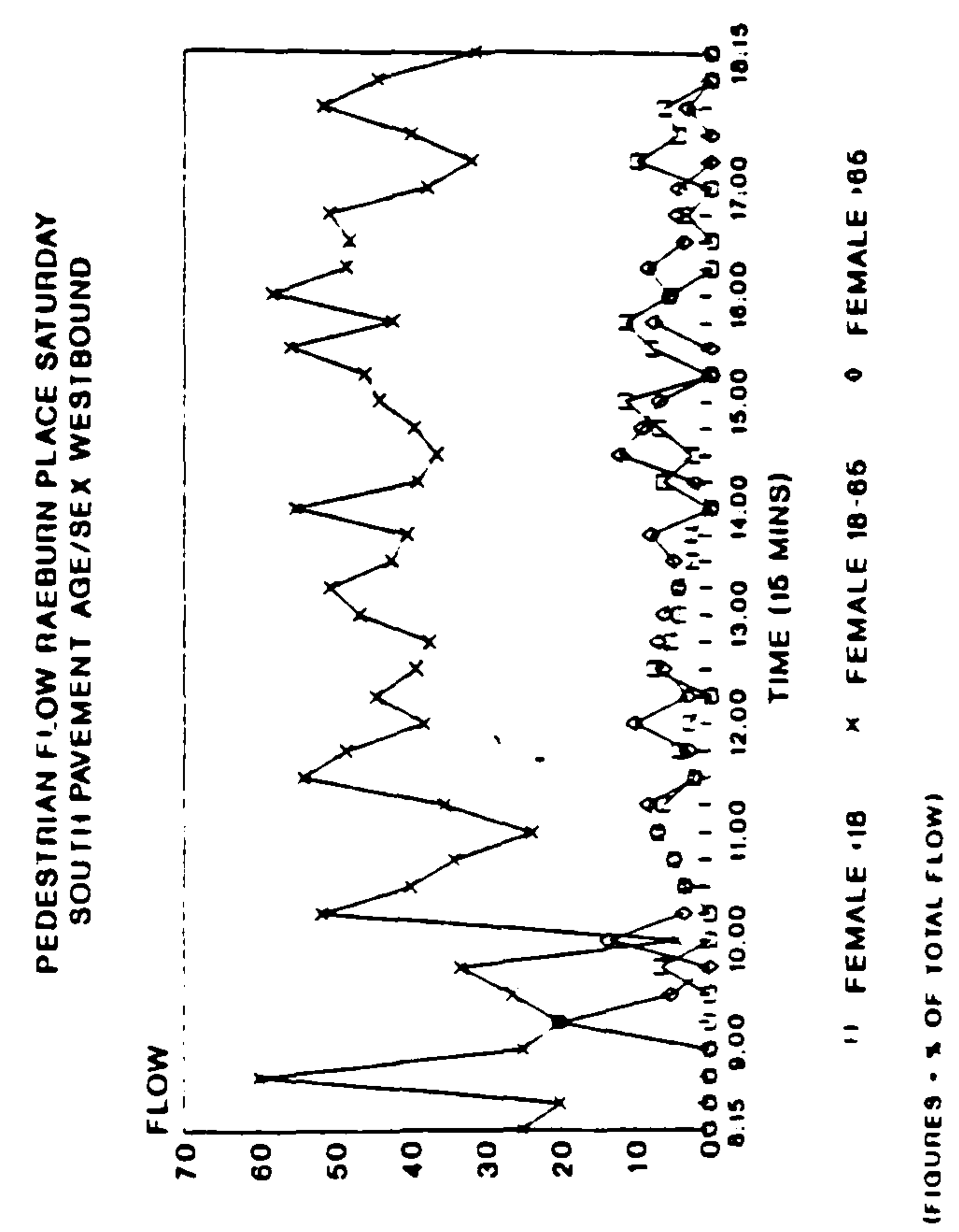


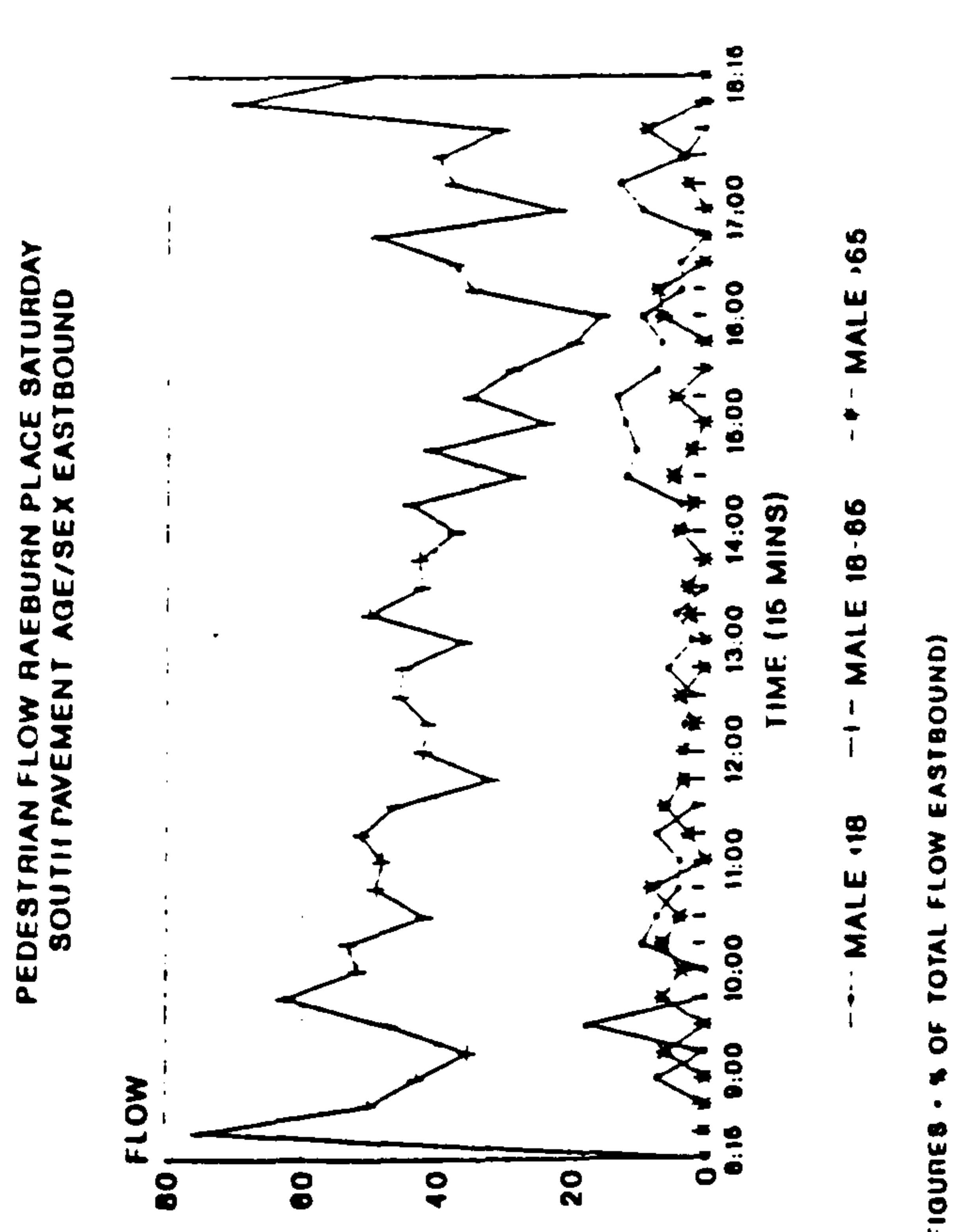


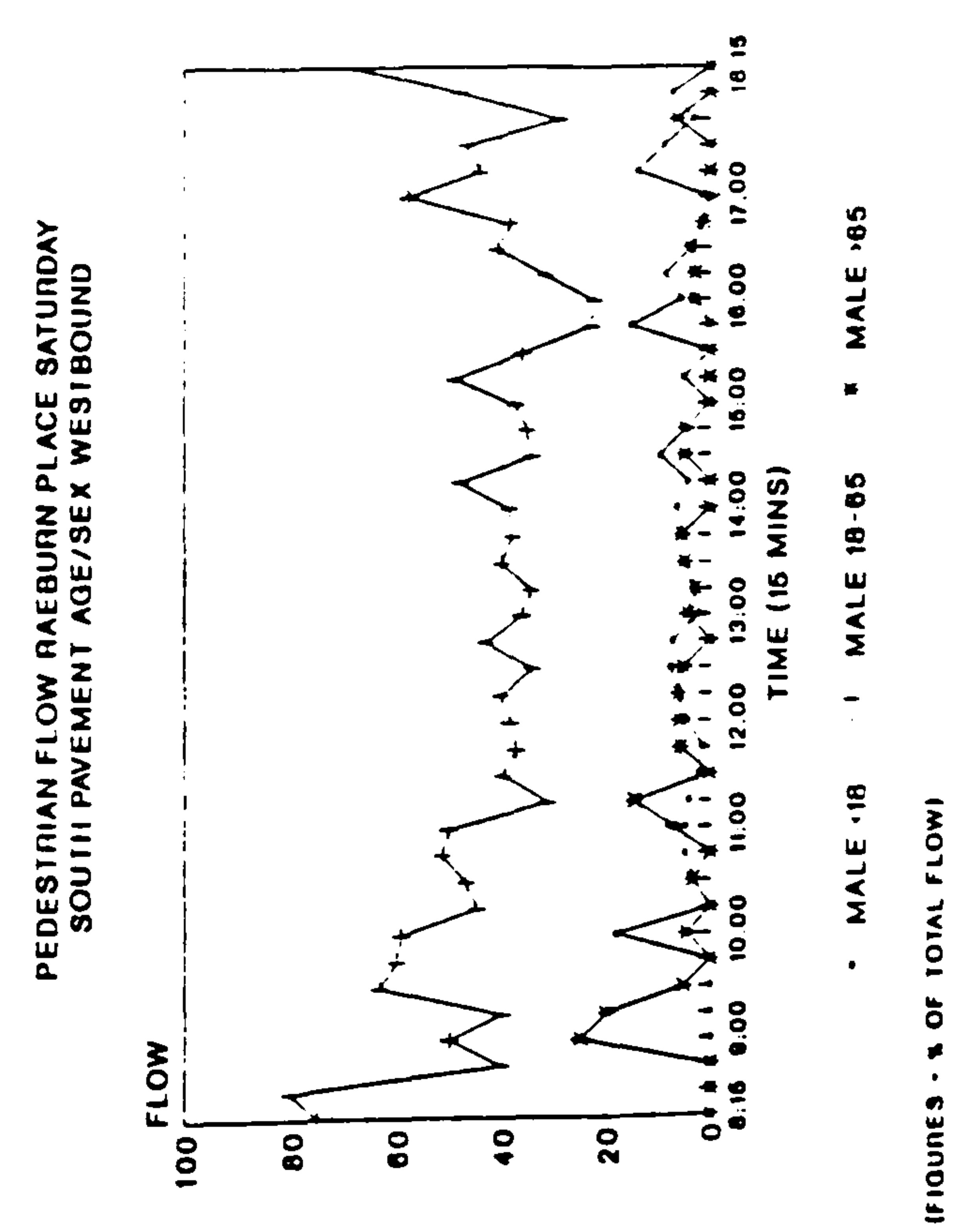


Pedestrian Flow, South Pavement, Thursday, by Age and Sex, Raeburn Place.

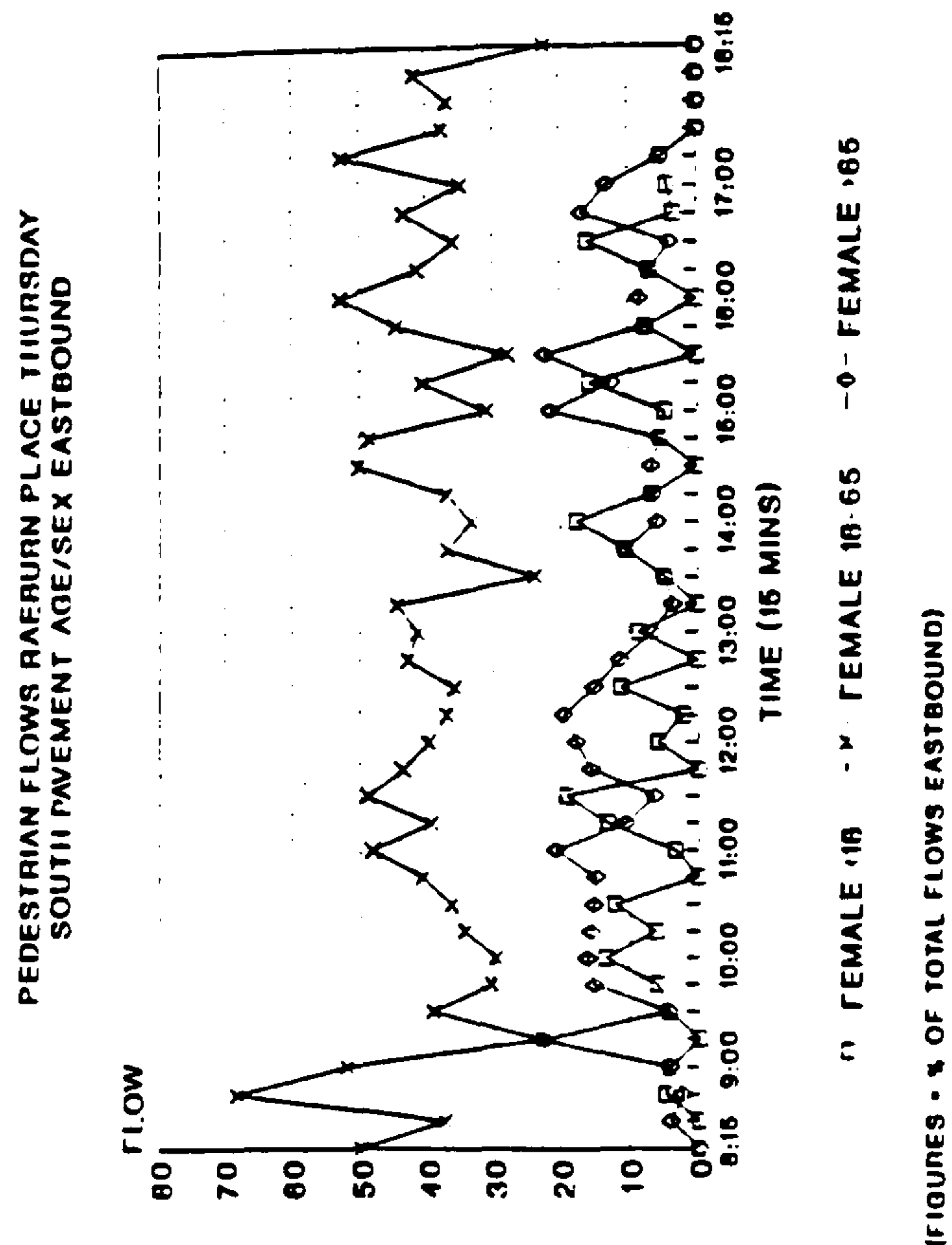


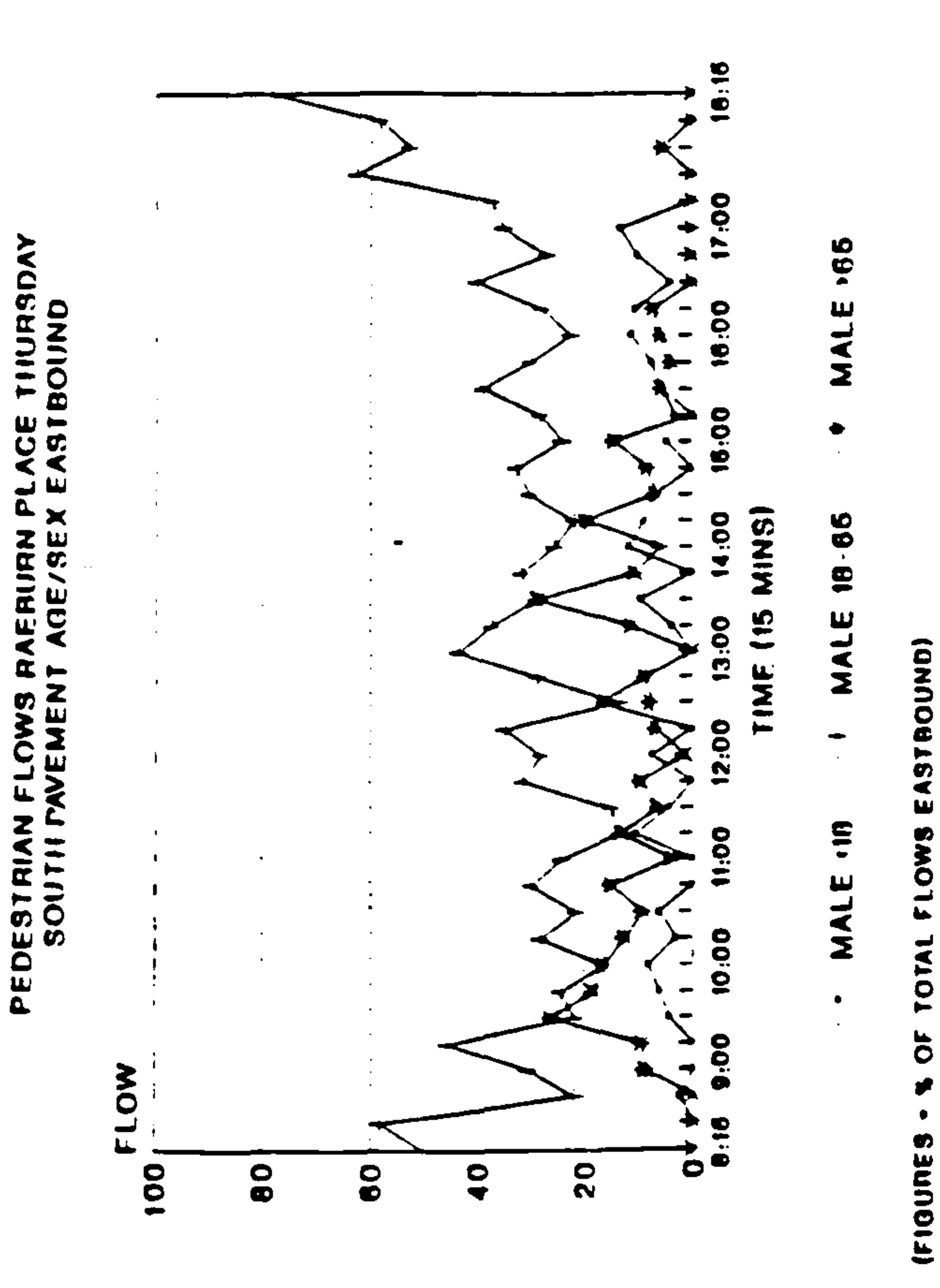


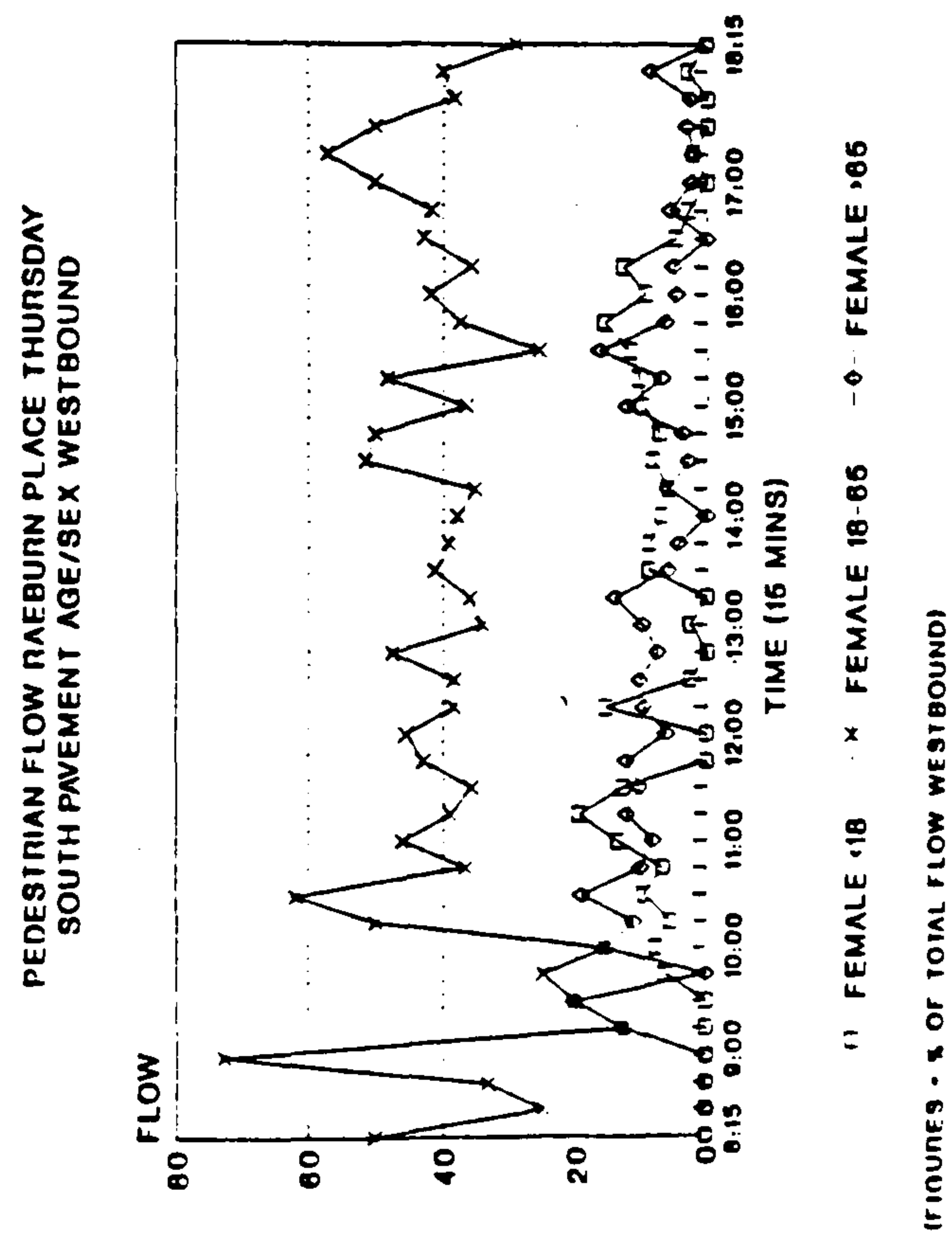


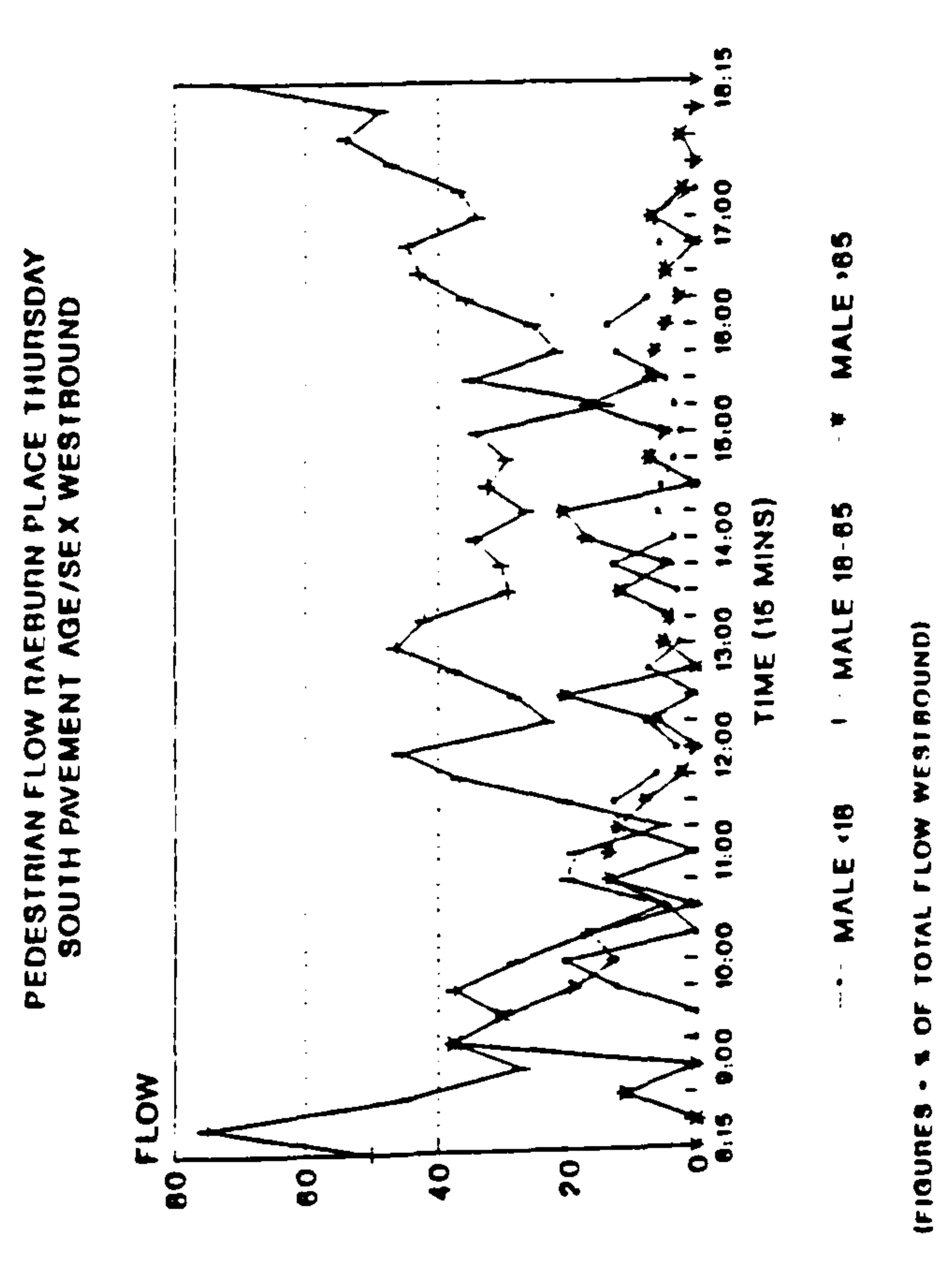


Pedestrian Flow, South Pavement, Saturday, by Age and Sex, Raeburn Place.

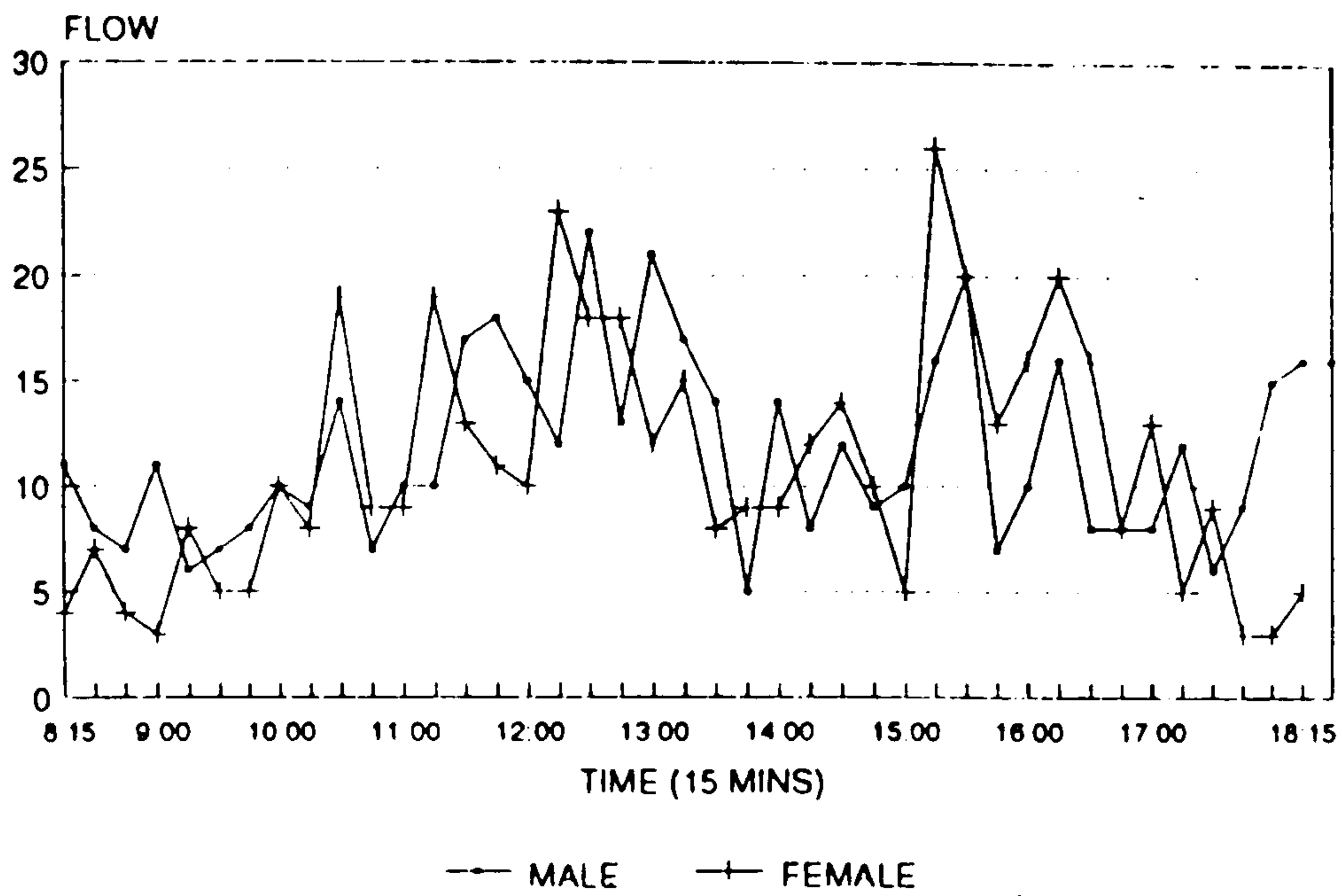




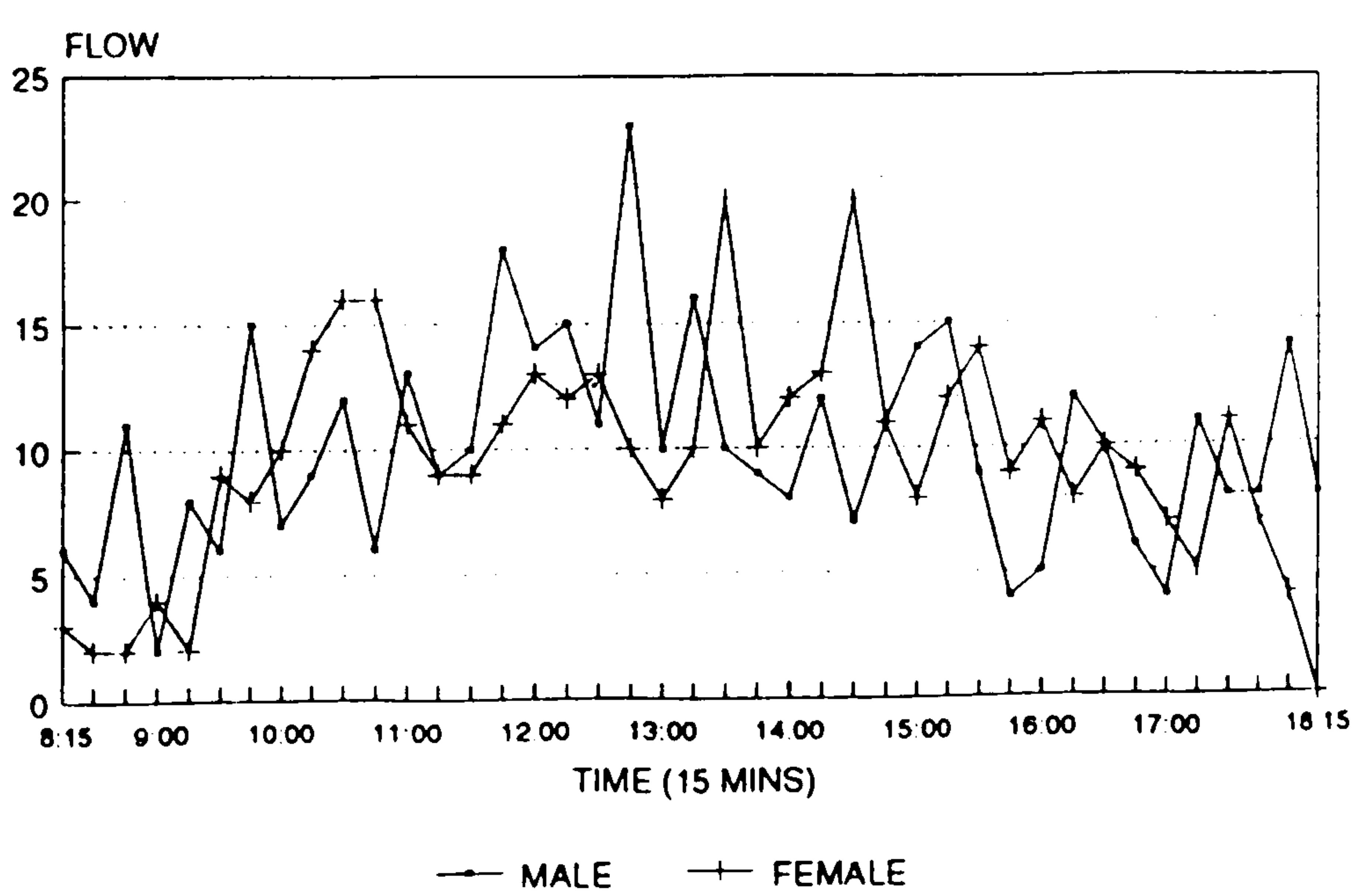




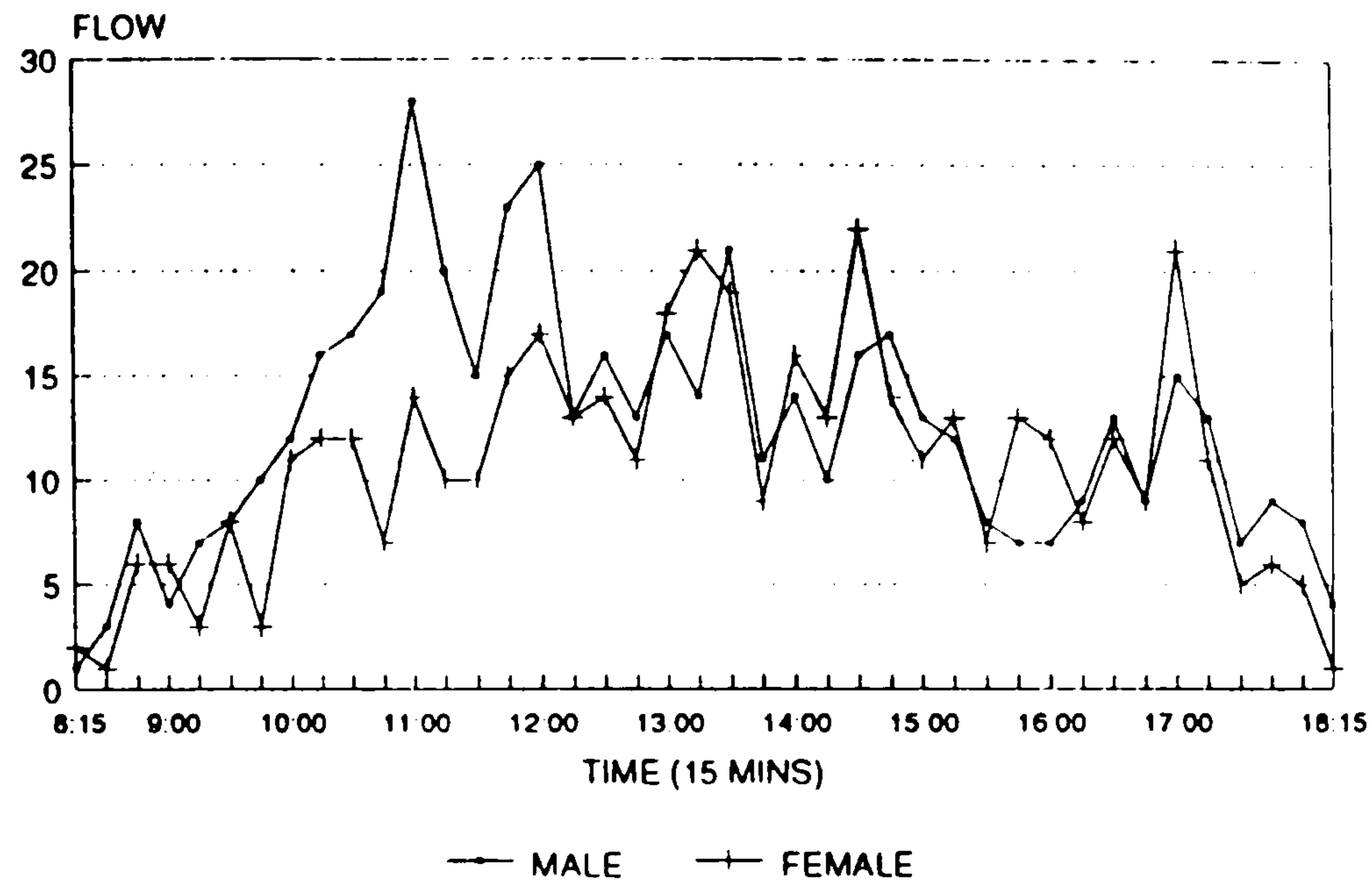
Pedestrian Crossing Flows, Northern Pavement, Tuesday, by Sex, Raeburn Place.



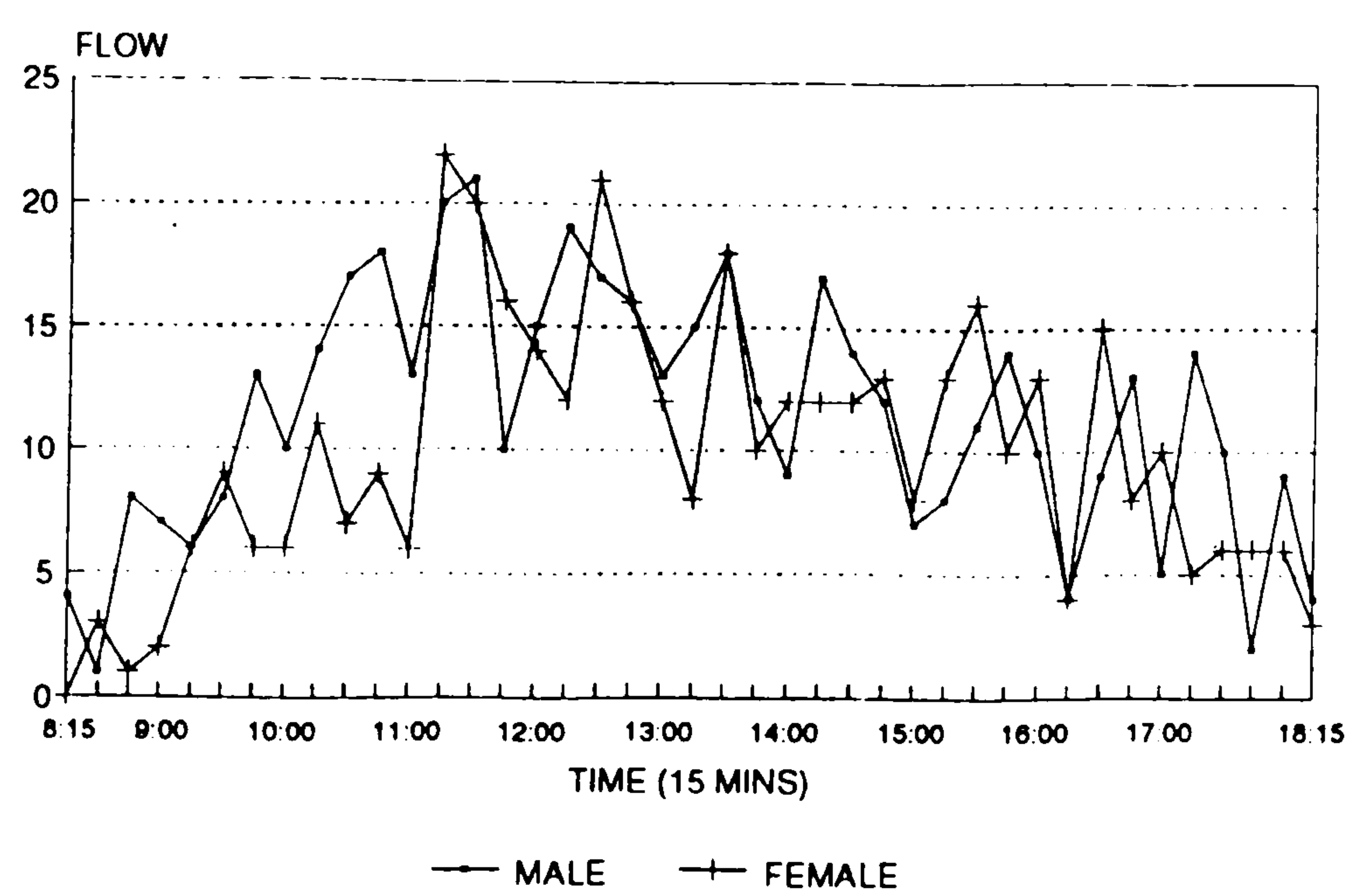
Pedestrian Crossing Flows, Southern Pavement, Tuesday, by Sex, Raeburn Place.



Pedestrian Crossing Flows, Northern Pavement, Saturday, by Sex, Raeburn Place.



Pedestrian Crossing Flows, Southern Pavement, Saturday, by Sex, Raeburn Place.



Trip Frequency and Employment Status, Raeburn Place.

Trip Frequency *Sample Number*[1]	Full *57* %	Part-time *22* %	None *66* %	Student *35* %
Up to 2 Trips a Week	5.3	9.1	34.3	2.9
3-5 Trips a Week	12.3	22.7	26.9	34.3
1 Trip a Day	36.8	18.2	16.4	17.1
2 Trips a Day	26.3	31.8	10.4	31.4
Over 2 Trips a Day	19.3	18.2	11.9	14.3

Note
[1] Sample number refers to number of respondents.

Average Length of Time of Walking Trip by Sex, Raeburn Place.

Average Length of Time of Walking Trip (mins) *Sample Number*[1]	Male *77* %	Female *103* %
Less than 10	26.0	10.7
10-20	36.4	47.6
20-30	26.0	22.3
Greater than 30	11.7	19.4

Note
[1] Sample number refers to number of respondents.

Average Length of Time of Walking Trip by Employment Status, Raeburn Place.

Average Length of Walking Trip (mins) *Sample Number*[1]	Full *57* *%*	Part-Time *22* *%*	None *66* *%*	Student *35* *%*
Less than 10	26.3	22.7	12.1	8.6
10-20	52.6	45.5	31.8	45.7
20-30	14.0	27.3	27.3	31.4
Greater than 30	7.0	4.5	28.8	14.3

Note
[1] Sample number refers to number of respondents.

Average Length of Time of Walking Trip by Average Distance of Walking Trip, Raeburn Place.

Average Length of Walking Trip (mins) *Sample Number*[1]	Less than 50 Yards *34* *%*	50 yards - 1 Mile *116* *%*	Greater than 1 Mile *30* *%*
Less than 10	52.9	11.2	0.0
10-20	29.4	56.0	6.7
20-30	14.7	22.4	40.0
Greater than 30	2.9	10.3	53.3

Note
[1] Sample number refers to number of respondents.

Average Length of Time of Walking Trip by Trip Purpose, Raeburn Place.

Average Length of Walking Trips (mins)	Sample Number[1]		Shopping	Shopping to/from Work	To/from work	Other	To/from School/ College
Less than 10	31	%	3.2	35.5	45.2	45.2	3.2
10-20	77	%	14.3	28.6	16.9	16.9	19.5
20-30	43	%	16.3	2.3	9.3	9.3	20.9
Over 30	29	%	3.4	3.4	13.8	13.8	17.2

Note
[1] Sample number refers to number of respondents.

Average Distance of Walking Trip by Trip Purpose, Raeburn Place.

Trip Purpose	Less than 50 Yards	50 Yards - 1 Mile	Greater than 1 Mile
Sample Number[1]	*34* %	*116* %	*30* %
Shopping	20.6	36.2	36.7
Shopping to/from Work	8.8	10.3	16.7
To/from Work	29.4	19.0	10.0
Other	38.2	17.2	6.7
To/from School/College	2.9	17.2	30.0

Note
[1] Sample number refers to number of respondents.

Car Availability by Age, Bruntsfield Place and Raeburn Place Resident Surveys.

Age	No Car Available	Car Available	No Car Available	Car Available
Sample Number[1]	*83* %	*58* %	*125* %	*55* %
Under 18	**3.6**	**0.0**	**12.8**	**5.5**
18-24	**49.4**	**25.0**	**26.4**	**14.5**
25-65	**42.4**	**73.2**	**28.8**	**69.1**
Over 65	**4.7**	**1.8**	**32.0**	**10.9**

Note
[1] **Sample number refers to number of respondents.**

APPENDIX 4
TRAFFIC SPEED AND PEDESTRIAN BEHAVIOURAL DATA

Traffic Speed Frequency Distribution Eastbound, Thursday, Raeburn Place.

Time Period % of Vehicles per Speed Level					
Traffic Speed (kmh) *Sample Number*[1]	0800-0915 *172* %	1130-1330 *213* %	1500-1730 *277* %	1845-2000 *127* %	2030-2200 *118* %
0-15	1.8	9.4	15.5	0.0	0.0
15-20	4.1	11.2	8.3	1.6	0.0
20-25	4.6	17.9	15.9	7.1	0.8
25-30	20.3	24.4	18.0	13.4	7.6
30-35	14.0	11.3	18.8	21.3	18.6
35-40	27.9	17.8	15.2	29.0	23.7
40+	27.3	8.0	8.3	27.6	49.3

Note
[1] Sample number refers to number of vehicles.

Traffic Speed Frequency Distribution Westbound, Thursday, Raeburn Place.

Time Period % of Vehicles per Speed Level					
Traffic Speed (kmh) *Sample Number*[1]	0800-0915 *172* %	1130-1330 *235* %	1500-1730 *329* %	1845-2000 *148* %	2030-2200 *87* %
0-15	0.0	3.0	1.5	0.0	0.0
15-20	0.0	11.2	8.8	1.4	1.1
20-25	1.2	23.4	18.6	6.1	15.0
25-30	12.2	35.4	37.1	25.7	28.8
30-35	18.0	14.0	21.9	23.0	23.0
35-40	30.8	10.5	10.6	27.7	26.4
40+	37.8	2.5	1.5	16.1	5.7

Note
[1] Sample number refers to number of vehicles.

Traffic Speed Frequency Distribution Eastbound, Saturday, Raeburn Place.

Time Period % of Vehicles per Speed Level					
Traffic Speed (kmh) *Sample Number*[1]	0800-0915 *91* %	1130-1330 *143* %	1500-1730 *202* %	1845-2000 *105* %	2030-2200 *103* %
0-15	1.1	39.2	10.4	1.0	0.0
15-20	2.2	15.4	8.4	0.0	0.0
20-25	5.5	9.1	8.9	4.8	1.0
25-30	15.4	18.2	22.8	4.8	3.9
30-35	25.3	11.2	18.8	15.2	7.8
35-40	0.0	4.9	19.8	27.6	20.3
40+	50.5	2.0	10.9	46.6	67.0

Note
[1] Sample number refers to number of vehicles.

Traffic Speed Frequency Distribution Westbound, Saturday, Raeburn Place.

Time Period % of Vehicles per Speed Level					
Traffic Speed (kmh) *Sample Number*[1]	0800-0915 *82* %	1130-1330 *186* %	1500-1730 *224* %	1845-2000 *104* %	2030-2200 *96* %
0-15	0.0	10.8	4.0	0.0	0.0
15-20	0.0	23.6	8.9	4.8	0.0
20-25	9.8	28.5	18.3	14.4	8.3
25-30	20.7	18.3	29.9	32.7	15.6
30-35	19.5	11.8	18.3	27.9	29.1
35-40	19.5	7.0	13.4	15.4	24.0
40+	30.5	0.0	7.2	4.8	23.0

Note
[1] Sample number refers to number of vehicles.

Pedestrian Delays, Bruntsfield Place and Raeburn Place.

Street	Sample Number[1]	Mean (secs)	Standard Error (secs)	Standard Deviation (secs)	Minimum (secs)	Maximum (secs)
Bruntsfield Place	337	10.8	0.5	9.5	1.0	54.5
Raeburn Place	312	13.4	0.6	11.1	1.6	56.0

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delays by Age, Bruntsfield Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	10	16.9	3.6	11.2	3.0	36.2
18-65	299	10.5	0.5	9.2	1.0	54.5
Over 65	28	12.7	2.0	10.6	2.4	45.0

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delays by Age, Raeburn Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	87	12.6	1.2	11.1	2.0	56.0
18-65	98	12.3	1.0	9.6	1.6	56.0
Over 65	127	14.7	1.1	12.0	2.2	53.3

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delays for Pedestrians Alone and Accompanied, Bruntsfield Place and Raeburn Place.

	Bruntsfield Place		Raeburn Place	
Statistic (secs) *Sample Number*[1]	Alone *465*	Accompanied *82*	Alone *209*	Accompanied *103*
Mean	10.3	12.3	12.5	15.2
Standard Error	0.6	1.0	0.7	1.3
Standard Deviation	9.5	9.3	10.0	12.8
Minimum	1.0	2.0	1.6	2.0
Maximum	54.5	36.2	53.3	56.0

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delay and Age, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Under 18 *156*	18-65 *179*	Over 65 *180*
Nearside Traffic Flow	0.1671	0.2496	0.4693
Farside Traffic Flow	0.4150	0.1624	0.1741
Total Flow	0.4420	0.3156	0.4406
Traffic Speed Nearside	-0.1700	-0.2036	-0.0094
Traffic Speed Farside	-0.0970	-0.0813	-0.2462
Accept. Gap Nearside	-0.0721	-0.1325	-0.0251
Accept. Gap Farside	-0.2010	-0.1471	-0.1400
Crossing Angle Nearside	0.0433	0.1764	0.1727
Crossing Angle Farside	0.0433	0.1764	0.1727
Total Crossing Time	0.9549	0.8523	0.9617
Number of Parked Vehicles	0.0142	-0.0461	0.0799

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delay and Sex, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Male *203*	Female *312*
Nearside Traffic Flow	0.3459	0.2804
Farside Traffic Flow	0.1901	0.2660
Total Traffic Flow	0.3955	0.3942
Traffic Speed Nearside	-0.1608	-0.0824*
Traffic Speed Farside	-0.1223*	-0.1825
Acceptance Gap Nearside	-0.0846	-0.0483*
Acceptance Gap Farside	-0.0804*	-0.2239
Crossing Angle Nearside	0.1727	0.1370
Crossing Angle Farside	0.1727	0.1370
Total Crossing Time	0.9450	0.9219
Number of Parked Vehicles	0.0646*	0.0071*

Note
[1] Sample number refers to number of pedestrians.
* Not significant.

Pedestrian Delay and Walking Situation, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Alone *337*	Accompanied *178*
Nearside Traffic Flow	0.3472	0.2371*
Farside Traffic Flow	0.1647	0.3342
Total Traffic Flow	0.3780	0.4166
Traffic Speed Nearside	-0.0795*	-0.1570
Traffic Speed Farside	-0.1880	-0.1135*
Acceptance Gap Nearside	-0.0381*	-0.1018*
Acceptance Gap Farside	-0.1428	-0.2134
Crossing Angle Nearside	0.1672	0.1060*
Crossing Angle Farside	0.1672	0.1060*
Total Crossing Time	0.8931	0.9752
Number of Parked Vehicles	0.1127	-0.1091*

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delay and Delay Position, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Gutter *89*	Pavement *30*	Offside Parked Vehicle *177*	In Carriageway *16*
Nearside Traffic Flow	0.2065	0.1845*	0.1037*	-0.0110*
Farside Traffic Flow	-0.0360*	0.1915*	0.3154	0.1377*
Total Traffic Flow	0.1276*	0.3057*	0.3599	0.2194*
Nearside Traffic Speed	-0.0861*	0.2894*	-0.1625	0.4552*
Farside Traffic Speed	-0.2135	-0.1624	-0.1722	-0.0361*
Acceptance Gap Nearside	0.0648*	0.2218*	0.0393*	0.4154*
Acceptance Gap Farside	-0.0786*	-0.0767*	-0.1523	-0.0726*
Crossing Angle Nearside	0.2730	0.2520*	-0.0140*	-0.3732*
Crossing Angle Farside	0.2730	0.2520*	-0.0140*	-0.3732*
Total Crossing Time	0.9723	0.9637	0.9569	0.8928
Number of Parked Vehicles	-0.0904	0.0869*	-0.0661*	-0.2252*

Note
[1] Sample number refers to number of pedestrians.

Pedestrian Delay and Crossing Behind Parked Vehicles, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Crossing Behind Parked Vehicle *312*	Not Crossing Behind Parked Vehicle *203*
Nearside Traffic Flow	0.3073	0.2866
Farside Traffic flow	0.3044	0.1601
Total Flow	0.4508	0.3221
Nearside Traffic Speed	-0.1268	-0.0685*
Farside Traffic Speed	-0.1801	-0.1331
Acceptance Gap Nearside	-0.1302	0.0825*
Acceptance Gap Farside	-0.2207	-0.0955*
Crossing Angle Nearside	0.0553*	0.2704
Crossing Angle Farside	0.0553*	0.2704
Total Crossing Time	0.9137	0.9571
Number of Parked Vehicles	-0.0452*	0.0922*

Note
[1] Sample number refers to number of pedestrians.
* Not Significant.

Crossing Angles, Raeburn Place.

Carriageway	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Nearside	515	78.2	0.8	17.0	18.0	90.0
Farside	515	78.2	0.8	17.0	18.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angles, Bruntsfield Place.

Carriageway	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Nearside	592	70.8	0.9	20.9	13.0	90.0
Farside	591	70.5	0.9	21.2	10.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angles by Age, Both Carriageways, Raeburn Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	156	77.2	1.3	16.4	30.0	90.0
18-65	179	76.8	1.4	18.7	18.0	90.0
Over 65	180	80.4	1.2	15.5	25.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angles by Age, Both Carriageways, Bruntsfield Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	12	76.8	6.3	21.7	28.0	90.0
18-65	544	70.1	0.9	21.1	13.0	90.0
Over 65	36	80.8	2.4	14.5	35.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angle and Walking Situation, Both Carriageways, Raeburn Place.

Walking Situation	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Alone	337	76.9	1.0	18.3	18.0	90.0
Accompan-ied	178	80.5	1.0	13.8	35.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angle and Walking Situation, Both Carriageways, Bruntsfield Place.

Walking Situation	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Alone	465	70.8	1.0	20.9	15.0	90.0
Accompan-ied	127	71.1	1.9	21.1	13.0	90.0

Note
[1] Sample number refers to number of pedestrians.

Crossing Angle and Age, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Under 18 (r) *156*	18-65 (r) *179*	Over 65 (r) *180*
Kerb Delay	0.0433*	0.1764	0.1727
Nearside Traffic Flow	0.1668	0.2100	0.0635*
Farside Traffic Flow	-0.0258*	0.0924*	-0.0396*
Total Flow	0.0950*	0.2302	0.0148*
Nearside Traffic Speed	0.0731*	-0.0769*	-0.0860*
Farside Traffic Speed	-0.1530*	-0.2172	-0.0151*
Acceptance Gap Nearside	-0.0903*	-0.0748*	-0.0625*
Acceptance Gap Farside	-0.0041*	0.0070*	-0.0598*
Total Crossing Time	-0.0502*	-0.0279*	0.0880*
Number of Parked Vehicles	-0.0507*	0.0759*	0.1741

Note
[1] Sample number refers to number of pedestrians.

Crossing Angle and Walking Situation, Correlation Coefficients, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Alone (r) *337*	Accompanied (r) *178*
Kerb Delay	0.1672	0.1060*
Nearside Traffic Flow	0.1506	0.1501
Farside Traffic Flow	0.0249*	-0.0184*
Total Flow	0.1293	0.0846*
Nearside Traffic Speed	-0.0424*	0.0309*
Farside Traffic Speed	-0.1491	-0.0898*
Acceptance Gaps Nearside	-0.0886*	-0.0498*
Acceptance Gaps Farside	-0.0309*	0.0083*
Total Crossing Time	0.0095*	0.0516*
Number of Parked Vehicles	0.1473	-0.1495

Note
[1] Sample number refers to number of pedestrians.

Crossing Angles and Sex, Correlation Coefficients, Raeburn Place.

Behavioural Measure	Male (r)	Female (r)
Sample Number[1]	*203*	*312*
Kerb Delay	0.1727	0.1370
Nearside Traffic Flow	0.0633*	0.1904
Farside Traffic Flow	0.0019*	0.0325*
Total Flow	0.0459*	0.1586
Nearside Traffic Speed	-0.0908*	0.0017*
Farside Traffic Speed	-0.1497*	-0.1196
Acceptance Gaps Nearside	-0.1066*	-0.0383*
Acceptance Gaps Farside	-0.0317*	-0.0192*
Total Crossing Time	0.0852*	0.0009
Number of Parked Vehicles	0.0838*	0.2317

Note
[1] Sample number refers to number of pedestrians.
* Not significant

Acceptance Gaps (seconds), Bruntsfield Place.

Carriageway	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Nearside	582	15.6	0.4	10.7	0.9	60.0
Farside	578	14.2	0.4	8.6	2.4	51.4

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps (seconds), Raeburn Place.

Carriageway	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Nearside	498	21.5	0.6	12.5	4.0	75.0
Farside	502	20.2	0.6	12.8	3.0	93.4

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps (seconds) by Age, Nearside Carriageway, Raeburn Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	147	21.3	1.0	12.1	4.6	60.0
18-65	176	20.4	0.9	12.4	4.0	71.0
Over 65	175	22.7	1.0	12.9	5.2	75.0

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps (seconds) by Age, Farside Carriageway, Raeburn Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	155	20.4	1.0	12.3	3.2	54.4
18-65	174	21.0	1.0	13.6	3.6	62.6
Over 65	173	19.0	0.9	12.4	3.0	93.4

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps (seconds) by Age, Nearside Carriageway, Bruntsfield Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	12	14.2	2.8	9.7	5.0	31.0
18-65	536	15.8	0.5	10.7	0.9	60.0
Over 65	34	13.2	1.6	9.3	4.0	45.3

[1] Sample number refers to number of pedestrians.

Acceptance Gaps (seconds) by Age, Farside Carriageway, Bruntsfield Place.

Age	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Under 18	12	14.8	2.8	9.7	5.4	40.0
18-65	531	14.2	0.4	8.7	2.4	51.4
Over 65	35	14.1	1.2	7.0	3.7	31.4

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps by Walking Situation, Nearside and Farside Carriageways, Raeburn Place.

	Nearside Carriageway		Farside carriageway	
Statistic	Alone	Accompanied	Alone	Accompanied
Sample Number[1]	*328*	*170*	*331*	*171*
Mean	20.5	23.5	20.3	19.8
Standard Error	0.7	0.9	0.7	0.9
Standard Deviation	12.7	11.9	13.5	11.5
Minimum	4.0	5.8	3.0	3.2
Maximum	75.0	60.0	93.4	54.4

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps by Walking Situation, Nearside and Farside Carriageways, Bruntsfield Place.

	Nearside Carriageway		Farside carriageway	
Statistic	Alone	Accompanied	Alone	Accompanied
Sample Number[1]	*458*	*124*	*451*	*127*
Mean	15.8	14.9	14.2	14.2
Standard Error	0.5	0.8	0.4	0.8
Standard Deviation	11.1	8.8	8.6	8.6
Minimum	0.9	4.0	2.4	3.0
Maximum	60.0	50.6	51.4	40.0

Note
[1] Sample number refers to number of pedestrians.

Acceptance Gaps and Age, Correlation Coefficients, Nearside Carriageway, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Under 18 (r) *156*	18-65 (r) *179*	Over 65 (r) *180*
Kerb Delay	-0.0721*	-0.1325*	-0.0251*
Nearside Traffic Flow	-0.3360	-0.3642	-0.3119
Farside Traffic Flow	0.0171*	0.2224	0.0385
Total Traffic Flow	-0.2189	-0.0939*	-0.1836
Nearside Traffic Speed	0.2510	0.3004	0.1387
Farside Traffic Speed	0.0625*	0.1701	0.0585
Crossing Angle Nearside	-0.0903*	-0.0748*	-0.0625
Crossing Angle Farside	-0.0903*	-0.0748*	-0.0625
Total Crossing Time	-0.0103*	-0.0444*	-0.0022
Number of Parked Vehicles	-0.0635*	0.0294	-0.1282

Note
[1] Sample number refers to number of pedestrians.
* Not significant.

Acceptance Gaps and Age, Correlation Coefficients, Farside Carriageway, Raeburn Place.

Behavioural Measure *Sample Number*[1]	Under 18 (r) *156*	18-65 (r) *179*	Over 65 (r) *180*
Kerb Delay	-0.2010	-0.1471	-0.1400*
Nearside Traffic Flow	0.0787*	0.0545*	-0.0039*
Farside Traffic Flow	-0.5532	-0.4206	-0.4915
Total Traffic Flow	-0.3808	-0.2950	-0.3510
Nearside Traffic Speed	0.2184	0.0454	0.1150*
Farside Traffic Speed	0.2778	0.1533	0.2071
Crossing Angle Nearside	-0.0041*	0.0070*	-0.0598*
Crossing Angle Farside	-0.0041*	0.0070*	-0.0598*
Total Crossing Time	-0.2114	-0.0853*	-0.1394*
Number of Parked Vehicles	-0.1965	-0.0044*	-0.1275*

Note
[1] Sample number refers to number of pedestrians.
* Not significant.

Acceptance Gaps and Walking Situation, Nearside and Farside Carriageways, Correlation Coefficients, Raeburn Place.

	Nearside Carriageway		Farside Carriageway	
Behavioural Measure	**Alone (r)**	**Accompanied (r)**	**Alone (r)**	**Accompanied (r)**
Sample Number[1]	*337*	*178*	*337*	*178*
Kerb Delay	**-0.0381**	**-0.1018***	**-0.1428**	**-0.2134**
Nearside Traffic Flow	**-0.3374**	**-0.2600**	**0.0196**	**0.0939***
Farside Traffic Flow	**0.1148**	**0.0520***	**-0.4274**	**-0.5953**
Total Traffic Flow	**-0.1918**	**-0.1308***	**-0.3042**	**-0.4019**
Nearside Traffic Speed	**0.2591**	**0.1997**	**0.0444**	**0.2785**
Farside Traffic Speed	**0.0682***	**0.1516**	**0.1360**	**0.3459**
Nearside Crossing Angle	**-0.0886***	**-0.0498***	**-0.0309***	**0.0083***
Farside Crossing Angle	**-0.0886***	**-0.0498***	**-0.0309***	**0.0083***
Total Crossing Time	**0.0362***	**-0.0723***	**-0.1163**	**-0.2205**
Number of Parked Vehicles	**-0.0924***	**0.0018***	**-0.0833**	**-0.1467**

Note
[1] **Sample number refers to number of pedestrians.**

Acceptance Gaps and Sex, Correlation Coefficients, Nearside and Farside Carriageways.

	Nearside Carriageway		Farside Carriageway	
Behavioural Measure *Sample Number*[1]	Male (r) *203*	Female (r) *312*	Male (r) *203*	Female (r) *312*
Kerb Delay	-0.0846*	-0.0483*	-0.0804	-0.2239
Nearside Traffic Flow	-0.3275	-0.3463	0.0558*	0.0373*
Farside Traffic Flow	0.1529	0.0575*	-0.4469	-0.5102
Total Traffic Flow	-0.1060*	-0.2027	-0.3214	-0.3491
Nearside Traffic Speed	0.1962	0.2514	0.0819	0.1517
Farside Traffic Speed	0.1157*	0.0767*	0.1196	0.2727
Crossing Angle Nearside	-0.1066	-0.0383*	-0.0317*	-0.0192
Crossing Angle Farside	-0.1066	-0.0383*	-0.0317*	-0.0192
Total Crossing Time	-0.0299*	0.0043	-0.0912*	-0.1938
Number of Parked Vehicles	-0.0146*	-0.0751*	-0.0711*	-0.1319

Note
[1] Sample number refers to number of pedestrians.
* Not Significant.

Delay in the Centre (seconds), Raeburn Place and Bruntsfield Place.

Street	Sample Number[1]	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Bruntsfield Place	87	6.6	0.5	5.1	1.2	26.0
Raeburn Place	39	4.9	0.4	2.2	2.2	11.0

Note
[1] Sample number refers to number of pedestrians.

Regression Equations for Pedestrian Delay

All Age Groups

Independent Variable	Equation	T-Value	Significance of T (%)
Total Traffic Flow	Y=1.06+1.39xf	9.743	100
Nearside Traffic Speed Total Traffic Flow	Y=0.03-0.034xsn+1.37xf	-0.763 9.353	56 100
Farside Traffic Speed Nearside Traffic Speed Total Traffic Flow	Y=1.61-0.05xsf-0.0029xsn+1.325xf	-1.181 -0.651 8.749	77 49 100

Under 18 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Total Traffic Flow	Y=2.97+1.55xf	6.115	100
Nearside Traffic Speed Total Traffic Flow	Y=-0.32-0.85xsn+1.49xf	-1.170 5.771	76 100
Farside Traffic Speed Nearside Traffic Speed Total Traffic Flow	Y=-2.3+0.06xsf-0.08xsn+1.55xf	0.716 -1.184 5.692	52 77 100

18-65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Total Traffic Flow	Y=0.09+0.98xf	4.425	100
Nearside Traffic Speed Total Traffic Flow	Y=4.23-0.12xsn+0.87	-1.612 3.759	90 100
Farside Traffic Speed Nearside Traffic Speed Total Traffic Flow	Y=4.28-0.001xsf-0.12xsn+0.87xf	-0.028 -1.586 3.701	3 89 100

Over 65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Total Traffic Flow	Y=-0.425+1.66xf	6.549	100
Nearside Traffic Speed Total Traffic Flow	Y=-2.72+0.07xsn+1.69xf	0.911 6.607	64 100
Farside Traffic Speed Nearside Traffic Speed Total Traffic Flow	Y=1.55-0.147xsf+0.009xsn+1.55xf	-1.842 1.121 5.823	94 74 100

Regression Equations for Nearside Acceptance Gaps

All Age Groups

Independent Variable	Equation	T-Value	Significance of T (%)
Nearside Traffic Flow	Y=27.86-2.02xf	-8.148	100
Nearside Traffic Speed Nearside Traffic Flow	Y=21.22+0.22xs-1.84xf	4.06 -7.4	100 100

Under 18 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Nearside Traffic Flow	Y=27.3-2.09xf	-4.428	100
Nearside Traffic Speed Nearside Traffic Flow	Y=20.2+0.24xs-1.86xf	2.593 -3.964	99 100

18-65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Nearside Traffic Flow	Y=27.6-2.04xf	-5.203	100
Nearside Traffic Speed Nearside Traffic Flow	Y=18.57+0.28xs-1.67xf	2.790 -4.090	100 100

Over 65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Nearside Traffic Flow	Y=28.5-1.91xf	-4.38	100
Nearside Traffic Speed Nearside Traffic Flow	Y=23.9+0.17xs-1.87xf	1.754 -4.317	92 100

Regression Equations for Farside Acceptance Gaps

All Age Groups

Independent Variable	Equation	T-Value	Significance of T (%)
Farside Traffic Flow	Y=27.9-2.7xf	-12.45	100
Farside Traffic Speed Farside Traffic Flow	Y=23.52+0.15xs-2.57xf	3.02 -11.747	99 100

Under 18 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Farside Traffic Flow	Y=29.1-2.94xf	-8.242	100
Farside Traffic Speed Farside Traffic Flow	Y=24.64+0.15xs-2.75xf	1.582 -7.335	89 100

18-65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Farside Traffic Flow	Y=27.86-2.44xf	-6.18	100
Farside Traffic Speed Farside Traffic Flow	Y=21.69+0.25xs-2.47xf	2.532 -6.356	99 100

Over 65 Years Old

Independent Variable	Equation	T-Value	Significance of T (%)
Farside Traffic Flow	Y=27.02-2.75xf	-7.53	100
Farside Traffic Speed Farside Traffic Flow	Y=25.064+0.06xs-2.65xf	0.775 -6.87	56 100

Note
xf=traffic flow
xs traffic speed

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